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THE COMPOUND OOSPHERE OF ALBUGO BLITI.

CONTRIBUTION FROM THE HULL BOTANICAL LABORATORY XVI.

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[*Concluded from p. 176.*]

RIPENING OF THE OOSPORE.

THE process by which the oospore attains its mature condition is easily divided into three stages, which are marked by changes that take place in the oospore wall, as follows: (1) a period during which the exospore is partially constructed, and which terminates with the beginning of (2) when the primary endospore is laid down and the exospore nearly completed, and (3) a period during which the secondary endospore is formed and the oospore becomes fully ripe and ready for its winter rest.

The nuclei in the oosphere withdraw from the immediate vicinity of the primitive wall soon after fusion of the sex nuclei, or even before this act is completed, and the strands of cytoplasm toward the center thicken, leaving those of the periplasm but little more than slender supporting threads. This condition is difficult to describe but is well represented in *fig. 89*. The vacuoles have previously enlarged and the cytoplasm is more granular than at any earlier stage. The primitive wall becomes about 0.75 μ thick.

At this time a peculiar substance appears in the interstices of the ooplasm and fills the large vacuoles. It is not seen in younger stages, but is constant at this period and takes a rusty color when Flemming's triple stain is used. When the substance first appears the tint is barely perceptible, but later it assumes a brick-red color. Slightly stained sections show a film in the vacuoles, often so curled up that an edge view is obtained, thus showing that the vacuoles actually contain a stainable substance. This substance is present in stages such as those represented in *figs. 91, 92, 93, 94*.

As the primitive wall reaches maturity it becomes covered by a layer of semi-transparent substance which is penetrated by straight pores. The condition is illustrated in *fig. 92*, where a portion of this layer lies in such a position that both a surface and an edge view appear at one time. As the pores are close together and straight the structure reminds one of the hymenial surface of the Polyporei. Since the main substance of the layer is nearly invisible, the pores appear dark and look like papillæ or cilia growing out of the primitive wall when seen in edge-view (*fig. 92*). A condition was noted by Wager in *A. candidus*, and referred to as the "columnar condition," which from the descriptions and drawings seems similar to this. There appear somewhat later in this semi-transparent layer peculiar saucer-shaped masses of a dark substance of unknown nature (*fig. 91*). They are the first indication of the ridges so characteristic of the mature epispore. There is but little periplasm at this period, although the nuclei of the periplasm are apparently still undiminished in number. However, they stain very lightly and show only a membrane and nucleolus. They frequently mass together in bunches, but there is no evidence that they disorganize to furnish material for the exospore as is described for *A. candidus*.

To complete the endospore the saucer-shaped regions, previously mentioned (*fig. 91*), extend laterally and run together, thus forming the ridges. This gives the epispore the structure shown in *fig. 93*. Nuclei persist much longer outside of the exospore, but they seem to be functionless, and their history was not followed

further. The mature endospore consists of two layers that may be called the primary and secondary endospores according to their development. The primary endospore appears as an even layer lining the primitive wall, at first agreeing precisely in stain reaction with the gelatinous material of the vacuoles, which is still present (*fig. 93*). The primary endospore, however, soon refuses this stain and gives the reaction of cellulose with chlor-iodide of zinc. A variation in the normal sequence was found in one oospore in that the epispore was completed before any trace of endospore was to be seen.

The conspicuous feature of the third period is the laying down of the secondary endospore inside of the first. It is of cellulose, and is about equal to the primary endospore in thickness. The two layers of the fully developed endospore are clearly evident when stained, also when they cleave apart in a perfectly regular manner as they frequently do (*fig. 97*). There seems to be a pause in the laying down of cellulose when the primary endospore is completed, as is shown by the fact that perceptible changes occur in the development of the epispore after the first and before the second endospore is formed. *Fig. 94* shows the earliest trace of the secondary endospore that was seen. When the second layer of cellulose is completed the gelatinous material has completely disappeared from the vacuoles. The fact that this substance appears just before the laying down of the primary endospore, the agreement in their staining reactions while the endospore is young, and the disappearance of all of the gelatinous material simultaneously with the completion of the secondary endospore, are significant facts. They indicate that this substance is intimately connected with the formation of the cellulose walls of the spore. It appears to be transferred directly from the vacuoles to the exterior of the protoplasm, there to change to true cellulose.

Finally, various food substances accumulate in the center of the oospore, taking the form of one very large irregularly shaped globule (*fig. 97*). Around this mass lies a zone of cytoplasm containing the fusion-nuclei in resting condition. Their number

is about one hundred, so it is not probable that there has been any multiplication since fertilization. Mitotic figures have never been seen in the oospore after that act, and it is probable that the oospore persists in this condition until the following spring.

OILS AND OTHER FOODS.

A thorough discussion of this subject would involve a much more elaborate microchemical study than was undertaken. It seems desirable, however, to record a few observations since these extra-protoplasmic substances are very conspicuous at certain periods of development and their presence often introduces serious difficulties of technique. No writer has given the subject the attention that it deserves, and detailed study would doubtless yield valuable results.

There are three substances which, when present, always appear as nearly spherical globules with the general appearance of oil, and they have undoubtedly been described as such by many previous observers. Further study may show that they are not true oils, and this seems quite probable, as they do not answer to all of the microchemical tests; but in the lack of a precise knowledge of their chemical nature they may be considered here under that name. All of them are found in the serial sections cut from paraffin, that is, in material which has passed in bulk through the weak alcohols and rested in 75 per cent. alcohol for weeks or months; which has passed to the paraffin through chloroform and been cleared of paraffin by immersion for a few moments in xylol; and finally which has undergone the baths accessory to the stain employed.

The first oil is very abundant, existing in far greater quantity than either of the others, and during more stages in the development of the fungus. It is found in the young oogonium, the oosphere, and the periplasm. Diagrams showing its distribution in the important periods of development are given in the plates. *Fig. 46* presents it for an oogonium of about the age shown in *fig. 45*. *Fig. 63* illustrates its distribution at zonation, and it should be noticed that the drops are small where the

meshes of the ooplasm are fine, but large in the periplasm where the meshes are more coarse. *Fig. 72* shows the condition of an oogonium at a stage similar to *fig. 70*, a period somewhat later than zonation. The distribution is much the same because the protoplasm has changed but little. *Fig. 81*, a stage after fertilization, indicates that as the meshes of the ooplasm become coarser the globules become larger; apparently some of the globules fuse to form the larger drops. A later stage similar to *fig. 93* shows that the oil of the periplasm is nearly exhausted during the building up of the epispore.

This most common oil is found in unstained sections as blackish or brown drops when the material has been killed by Flemming's fixing fluid. It is usually absent from material fixed by chrom-acetic acid, or if present is in very small quantity. If the material is allowed to remain several (six) days in the chrom-acetic fixing agent the oil appears in considerable quantity, very much as it does in Flemming's material, but of lighter straw color instead of brown. When material fails to show the oil, it seems to be really absent, because several days' immersion in 1 per cent. osmic acid solution fails to show its presence. Therefore, it seems that the osmic acid of the Flemming's fixing fluid, or the long immersion in chrom-acetic acid, so acts on the oil as to render it less easily soluble in the fluids that it meets between the killing and the time when the sections are stained. This oil when present takes a characteristic and beautiful red color from the safranin in the Flemming's triple stain combination. If it be very dark from the action of the osmic acid, it is frequently necessary to employ hydrogen peroxid to remove the blackness, in order that the best results may be obtained from the stains. It is partially on account of this oil that material killed by Flemming's fluid is not so favorable for cytological study as that fixed by the chrom-acetic acid.

The second oil-like substance is present only in very small quantity, possibly eight or ten small globules in an oogonium. It is evident in both Flemming and chrom-acetic material, is

stained black by Heidenhain's hæmatoxylin, but may be distinguished from the first oil by the fact that it does not take the safranin when applied in the usual way. It is figured in the plates as black dots (*figs. 51, 56, 59, 61, 64, 68, 69*); in the antheridium in *fig. 85*; in the periplasm in *fig. 80*. No difference in stain reaction was observed between this oil-like substance and the central globule of the cœnocentrum, and they may be of similar nature.

The third oil is only found in the maturing oospore, first appearing while the secondary endospore wall is developing as globules of a clear honey-yellow color in the meshes of the protoplasm (*fig. 95*). It soon accumulates at the wall, and *fig. 94* shows large drops in close contact with the forming secondary endospore, which has broken away from the primary endospore, probably owing to the impact of the knife in cutting. The drops finally become larger and more numerous, as is shown in *fig. 96*. From a study of subsequent stages it seems probable that these oil drops later break away from the wall irregularly, and unite to form the several large drops that are often found in older oospores. This results finally in the condition shown in *fig. 97*, where the entire central region is occupied by a curious irregular globular structure which stains much as the oils have stained in previous stages, but which is certainly not of fluid consistency. It probably represents reserve food material. If this structure represents a genuine oil drop in the living spore, we may have to do here with the shrunken and collapsed vesicle or membrane that encased it in life, and whose contents have been lost during the processes of technique. Its appearance would accord well with this view. From its size and the time of development in the oospore it is surely the structure described as oil by previous investigators, and is characteristic of the winter oospore.

GENERAL CONSIDERATIONS.

It seems well before closing to take a general view of the facts that have been presented, and of their relation to previous knowledge; also to point out more clearly than was possible

in earlier pages the broader significance of the phenomena described.

A mitotic division of the nuclei of fungi seems to have been first noticed by Sadeback ('83) in Exoascus, and has since been observed in various forms and carefully studied and described in a few papers.

The occurrence of a mitotic division in the oogonium of Albugo was discovered by Wager ('96) in *A. candidus*, and confirmed by Berlese ('98) in *A. Portulacæ*. Wager notes that the nuclei enlarge and divide, leaving one daughter nucleus imbedded in the central body while the other nuclei pass to the periplasm. The one division increases the nuclei from about 115 to about double that number. Berlese says the nuclei divide several times in *A. Portulacæ*, increasing the number from 30 or 40 to about 200. The account given in the present paper describes two approximately simultaneous divisions affecting all of the nuclei in both antheridium and oogonium, and these mitoses result in the formation of the sexual elements, numerous male and female nuclei. The second division is strikingly different from the first in the appearance of the nuclear elements, particularly the chromatin. This condition suggested the possibility of a reduction of chromatin, but careful study revealed no convincing evidence. The mitoses are characterized by the intranuclear formation of the spindle, the intranuclear centrosomes, the permanence of the nucleolus, and the entire absence of extranuclear radiation.

Wager described the disappearance of the nucleolus in early prophase, followed by the formation of chromosomes and then by the spindle development. He inclines toward the view that the spindle is derived from the linin. The membrane persists up to metaphase, and Wager did not follow the division further. Berlese, from observations similar to those of Wager, namely, the disappearance of the nucleolus in prophase, argues that the spindle fibers are derived from it. The behavior of the nucleolus in *A. Bliti* is different from that described by the writers mentioned, in that the structure remains apparent inside of the

nucleus through all stages of mitosis. However, since Wager studied this question only incidentally, and as Berlese gives no figures and his account is very brief, a detailed comparison of the species is impossible. Berlese reports from twelve to sixteen chromosomes, and seems to have been able to count them during the fusion of the sexual nuclei. Neither Berlese nor Wager give details of the mitosis later than prophase.

Wager reports that as near as he can estimate there are from twelve to sixteen chromosomes shown in the mitotic figures. In *A. Bliti* six are found with certainty in some anaphase nuclei, and twelve appear in some metaphase nuclei with equal certainty. It may be that when twelve are counted the chromosomes have already divided, and that they really belong to two rather than to one nucleus. However, this is not certain, and there is some evidence that makes it appear that there is a reduction in the number of chromosomes during the first mitosis, but this cannot be considered as proved.

Centrosomes were not observed in either *A. candidus* or *A. Portulacæ*, or in any other of the Phycomycetes, so far as the writer is aware; but they have been described in earlier papers for Ascomycetes (Gjurasin '93, Harper '95), and for Basidomycetes (Wager '92, Juel '98).

With such fundamental differences as have been indicated, it is useless to attempt to establish a type of mitosis for Albugo, or to attempt to determine the relationship of the group through cytology. The type here described for *A. Bliti*, while presenting a few deviations from the mode of mitosis in vogue among higher plants, is in no way a departure from the forms well known among the lower types of plants and animals.

It is impossible to generalize on the facts of morphology presented in this paper, because simple processes of fertilization have been described in all forms where homology would be sought. Until the behavior of the nuclei of other species of Albugo is known, it is impossible to say which is the anomalous form of the genus, *A. candidus* or *A. Bliti*. From a preliminary study of *A. candidus* it can be affirmed that *A. Bliti* is in most

ways far more favorable for study; its nuclei are larger, its periplasm more abundant, its developmental stages more strongly marked, and its antheridial tube larger. *Albugo candidus*, however, has a remarkable cœnocentrum, which will be much easier to study than that of *A. Bliti*, owing to its much greater size and more pronounced stain reaction. A problem of great importance lies in a comparative study of the cœnocentra of the genus.

The characteristic massing of the cytoplasm to form a rudimentary oosphere in *A. Bliti*, differing thus from the vacuolate oosphere of *A. candidus*, is not a wider divergence than might be expected in different species; nor is the variation in the cœnocentrum more than what might be regarded as a specific difference. If such variations are found to be more marked in other species the way may be clear to trace the relationship between plants with one oosphere and those with several oospheres in each oogonium; between forms which differentiate their periplasm after the manner of Vaucheria, and others that follow the habit of the Saprolegniaceæ in a parietal rather than a central massing. It must be left to future research to make clear the relationship that must exist between the multiple fertilization illustrated by *Albugo Bliti* and simple acts of fusion between sexual elements.

It may be that cytological investigation will show remarkable variations in many respects in this genus, and establish a chain of derivative forms. The Saprolegniaceæ are said to range from parthenogenesis to complete sexual fertilization. Should Albugo prove to be similarly rich in habits the present knowledge of relationships will be much increased.

METHODS, MATERIALS, AND STAINING REACTIONS.

The material upon which this investigation was based consisted of leaves, stems, and flower clusters of *Amaranthus retroflexus* L. and *A. hybridus* L. bearing the fungus. It was collected at Syracuse, N. Y., Columbus, Ohio, and Chicago, Ill. In all cases the species seemed to be unquestionably *Albugo Bliti* Biv.

(*C. Amaranti* Schw. *C. amarantaccarum* Zal.). The form described by Zalewski ('83) as a different species was not met. Oospores are very abundant on both leaves and stems, producing on the former characteristic blister-like patches that assume a blackish hue if the oospores ripen in sufficient quantity. In the stems their presence may be predicted from peculiar swellings, usually accompanied by a reddish coloration, the entire plant often being thus affected. In partially diseased plants the oospores are likely to be found in the inflorescence, which reacts much as does the stem, becoming swollen and red. The parts most favorable for study are the stems, but leaves and flowers often section more easily. In killing the material undesirable parts were cut away, and the portions apparently favorable were cut into small bits; leaves were scored, and stems and peduncles were cut in pieces about 2 to 4^{cm} long, deep incisions being made every 2^{mm} to give ready access to the killing agent. The killing with suitable solutions was apparently perfect, and was as good midway between incisions as where the solution immediately reached the tissue.

The killing agent giving the best results was chrom-acetic acid of the following formula: chromic acid 0.8 per cent., acetic acid 0.5 per cent. in water. The material was usually left in this solution from twelve to eighteen hours, then washed in five or six changes of water, allowing about two hours between changes. It was then successively transferred to 12, 25, 50, 75 per cent. alcohol, remaining about two hours in each grade, and was left in the last grade until it was practicable to imbed in paraffin. A variation in the above method, by which the material was left six days in chrom-acetic acid gave interesting results. It rendered the oil in the protoplasm much less soluble, but caused the loss of many of the details of the mitoses.

Flemming's chrom-osmic-acetic acid was employed in the same manner as the chrom-acetic acid, but was not so useful, since the sections were very much darkened by the osmic acid, thus necessitating elaborate methods of bleaching before a desirable stain could be obtained.

Other killing agents used were corrosive sublimate in saturated aqueous solution; hot corrosive-acetic-sublimate in alcohol; Carnoy's fluid; absolute alcohol; Hermann's fluid; and Merkel's fluid. Most of these gave far inferior results to that obtained by the chrom-acetic acid, and none surpassed it in effect.

In order to imbed in paraffin the material was transferred through 85, 95, and 100 per cent. alcohol to a mixture of absolute alcohol and chloroform, first of one third then of two thirds strength of chloroform. The specimens were left about two hours in each fluid, and were finally placed in pure chloroform. After the material had been left in chloroform for an hour a quantity of paraffin was added, and two hours later the material was warmed on the bath. After two hours of gentle heat it was removed to a warmer position, and later the most of the chloroform was poured off, melted paraffin substituted, and the whole kept in the bath at a temperature of about 55°. It was found advantageous during the whole process of imbedding to use very shallow dishes, as by this means most or all of the chloroform is driven off gradually by evaporation. Material was left in the bath in soft paraffin three or four hours, the paraffin being twice changed in the meantime to insure the removal of all chloroform. It was then cast in a cake, the final paraffin having a melting point of about 62°. Sections 3 to 5 μ in thickness were cut with a Jung sliding microtome and fastened to the slide with Mayer's albumen fixative.

Flemming's triple stain, used with chrom-acetic acid material, gave the best results. This stain demands the greatest attention in its use or failure is inevitable, as is well known by all who employ it. In general, the best results were attained by a bath of 30–60 min. in safranin, followed by a rinsing more or less prolonged in acid alcohol. The time here is entirely a matter of judgment, varying with the result desired; 30–90 sec. was a most usual time. After running down through the alcohols the slide was placed in saturated solution of gentian-violet for from 5–45 min. It was then rinsed in water and placed in orange

G from 5–25 sec.; a longer time may do no harm but probably 10–15 sec. is always sufficient. Wipe away excess of liquid and flood the slide twice with absolute alcohol, allowing the second lot of alcohol to remain on the slide until sufficient of the gentian-violet has been removed. The time required will depend on the material, the length of time it was in the gentian-violet, and the result desired. Drain rapidly with filter paper and flood with clove oil for one minute; drain, follow by cedar oil and cover in xylol balsam. If properly stained the host cell wall should be a light violet, the chromatin of the spirem and the chromosomes blue, nucleolus and centrosomes red, and cytoplasm slightly yellowish.

Hæmatoxylin stain was used, applied after the method of Heidenhain (iron-alum 2 hrs., hæmatoxylin 12–18 hrs., followed by the slow extraction of iron alum till the proper degree is reached). This treatment gave some beautiful results in contrast with the Flemming stain, and was particularly valuable in demonstrating the achromatic portion of the nuclear figure. Hartog's nigrosin-carmine stain, as used by Wager and Berlese, was tried repeatedly on corrosive sublimate material, but the results were far inferior to those afforded by Flemming's triple or Heidenhain's hæmatoxylin stains. However, it is possible to demonstrate, even with this combination, the presence of many nuclei in the oosphere and in the antheridial tube, and to recognize the principal features of the mitotic figures. Other stains employed were Delafeld's hæmatoxylin, Biondi-Ehrlich, and cyanin-erythrosin, but they were distinctly inferior in their results.

The following stain reactions were presented in the best preparations, and were attained by the Flemming's triple stain unless otherwise stated: chromatin blue or violet, black with Heidenhain's hæmatoxylin; nucleoli red, black with Heidenhain's hæmatoxylin; centrosomes as nucleoli; spindle fibers dark blue; cytoplasm yellowish; granules, mentioned on page 163, are only seen in preparations stained with Heidenhain's hæmatoxylin, and then black.

SUMMARY.

1. The oogonium when cut off from the parent hypha contains about 300 nuclei, which enlarge and divide mitotically while the oosphere is being differentiated.

2. The oosphere is differentiated through a massing of the cytoplasm of the oogonium. By this process the nuclei, usually in stages of mitosis, together with the vacuoles, are expelled from the central region, and there results a dense and coarsely vacuolate periplasm. This condition occurs when the antheridial tube is very short.

3. There is a stage called zonation in which the nuclei, usually in metaphase, are lined up around the ooplasm, some of the spindles lying across the definite boundary that separates ooplasm from periplasm. In the telophase of this mitosis about fifty daughter nuclei are found in the ooplasm.

4. The antheridium contains at first about thirty-five nuclei which divide twice mitotically, and simultaneously with the division in the oogonium and oosphere.

5. Previous to the entrance of the antheridial tube a papilla is found projecting from the oogonium into the antheridium.

6. The antheridial tube penetrates slowly, reaching the ooplasm at the time of zonation, later entering the oosphere and appearing as a conspicuously multinucleate structure. When it opens there are discharged about one hundred male nuclei which fuse with the female nuclei in pairs.

7. The sexual nuclei differ in form; the sperm being elongated and the egg spherical.

8. A peculiar central body, the cœnocentrum, develops as the oosphere matures and disappears before fertilization. Its function is unknown. There is some evidence of its being a dynamic center of the compound oosphere.

9. The mitoses are alike in the oogonium and antheridium. The spindle is intra-nuclear and there are no extra-nuclear radiations. The centrosomes are very prominent at metaphase, and are intra-nuclear. They could not be distinguished in the

resting nucleus. The nuclear membrane persists until after metaphase and the nucleolus is present throughout the division.

10. The primitive wall of the oospore first appears when the antheridial tube opens. Later the epispore is laid down upon it by the periplasm.

11. Two endospores are formed by the ooplasm after the development in the vacuoles of a peculiar substance which disappears as the endospores reach maturity.

12. After the complete encasement of the oospore it becomes rapidly filled with food-stuffs. A large central oil-like drop is present during the winter condition.

13. The fusion nuclei pass the winter in the resting condition without further perceptible change.

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EXPLANATION OF PLATES XI–XV.

All figures are from material killed in chrom-acetic acid and stained with Flemming's triple stain, unless otherwise indicated. The figures were sketched with an Abbé camera, using the following combinations of lenses: Zeiss 2^{mm} ap. 1.30, with compensating ocular 18 and 12; also Bausch & Lomb $^1/_{12}$, with ocular no. 4. These combinations give respectively the following magnifications when projected to the table level: 3300, 2200, and 1500 diameters. *Plate XI* was not reduced in reproduction. All other plates are three fourths of the original scale.

PLATE XI.

All drawings represent a magnification of 3300 diameters, and were studied with Zeiss lenses.

FIG. 1. Resting nucleus in mycelium, linin faint, nucleolus prominent.

FIG. 2. Nucleus in flowing cytoplasm near entrance of oogonium.

FIG. 3. Nucleus in antheridium, spirem stage, membrane faint.

FIG. 4. Prophase: small drops accumulated on the linin network, the thread itself thinner, nucleus becoming spindle-shaped, no centrosome visible.

FIG. 5. A stage somewhat later, linin threads have almost entirely disappeared, chromatin grains scattered through nucleus, nucleolus to the right, and remains of a linin strand to the left.

FIG. 6. Nucleus more spindle-shaped, globules arranged in the equatorial plate, at the poles round bodies about equal to the chromatin dots in size, no spindle fibers, the definite line bounding the whole of the nuclear membrane.

FIG. 7. Similar to *fig. 5*. The longitudinal lines probably chromatin which has not reached the equator, nucleolus at the left. This nucleus was crowded by a mass of others, hence its short form.

FIG 8. Similar to *fig. 7*. Fibers visible toward the poles. This spindle was formed in one of the strands supporting the forming oogonium, and was consequently much elongated by tension. It is from the oogonium shown in *fig. 62*.

FIG. 9. Chromosomes at the equator, spindle fibers very apparent at the poles, but not visible at the equator, nucleolus to left, membrane intact and inclosing the spindle.

FIG. 10. From oogonium shown in *fig. 60*. Cross section of a spindle, twelve chromosomes apparent (stained by hæmatoxylin from Flemming's material).

FIG. 11. Spindle mature, chromosomes closely grouped at the equator, centrosomes prominent, spindle brilliant and clear, nuclear membrane present but poorly stained (*fig 13*).

FIG. 12. Chromosomes splitting, membrane visible with nucleolus enclosed.

FIG. 13. Nucleolus large, nuclear membrane very definite, daughter chromosomes ready to separate. Only those in the highest focus are shown, several others being found at a deeper focus. The stain was particularly to show the membrane, and was not suitable for centrosomes.

FIG. 14. Anaphase: chromosomes separating, nucleus lying about midway, centrosomes still visible, whole nucleus staining dark and membrane indistinguishable from spindle fibers.

FIG. 15. Chromosomes nearing the poles, centrosomes not distinguished from them, nucleolus midway, slight traces of spindle fibers stretching across the middle space, cytoplasm in the ends of the nucleus stains darker than that of the central area.

FIG. 16. Whole spindle elongated, chromosomes massing together at the poles.

FIG. 17. Similar to *fig. 16*, but in a crowded position. Compare with *fig. 7*.

FIGS. 18 and 19 are from the periplasm of an oogonium of about the age shown in *fig. 67*, slightly younger than shown in *fig. 68*.

FIG. 18. Spindle fibers collapsing in the middle leading to the separation of the daughter nuclei, the fibers constituting the origin of the membrane of the daughter nucleus.

FIG. 19. A young daughter nucleus, nucleolus, membrane, and chromosomes.

FIG. 20. Same as *fig. 19* in resting stage, nucleolus prominent, linin faint.

FIGS. 21 and 22 are from the same oosphere, and in the condition shown in *figs. 68-70*.

FIG. 21. Same as *fig. 20* but passing into the spirem stage.

FIG. 22. Nucleus elongating preparatory to division. Compare *fig. 4*.

FIG. 23. Breaking of skein into chromosomes, centrosomes apparent.

FIG. 24. Spindle forming inside of nuclear membrane, nucleolus lying outside of the spindle.

FIG. 25. From an oospore of the condition shown in *fig. 70*. Spindle lying completely inside of the nuclear membrane, chromosomes grouping at the equator, and centrosomes well defined.

FIG. 26. Metaphase: chromosomes splitting, membrane, centrosomes, and fibers clear. Fibers apparently of about the same number as the chromosomes.

FIG. 27. Daughter chromosomes ready to leave the equator.

FIG. 28. Anaphase: chromosomes well separated, centrosomes visible, spindle fibers crossing the middle space, chromosomes six in number. From same oospore as *figs 24* and *27*. Compare with *fig. 16*.

FIG. 29. Later anaphase: chromosomes near the poles, area in which they rest darker stained than central portion.

FIG. 30. Similar to *fig. 18*. Spindle fibers collapsed and daughter nuclei ready to separate. From same oospore as *fig. 29*.

FIG. 31. A male nucleus from the entrance of antheridial tube. This nucleus is the same as the one marked X in *fig. 73*.

FIG. 32. A nucleus (sperm) in the tip of the same tube that contained that shown in *fig. 31*, also marked X. Wall of the antheridial tube, dense cytoplasm surrounding nuclei, sperm with nucleolus and mass of chromatin at anterior end.

FIG. 33. Tube open, elongated and pointed sperms escaping, showing a very faint linin network, one female nucleus shown. This is part of the drawing shown in *fig. 85*.

FIG. 34. A sperm approaching a female nucleus, linin more prominent than in *fig. 33*.

FIG. 35. A sperm in contact with a female nucleus, becoming more nearly round, and its linin still more prominent.

FIGS. 36 to 40. Various stages of fusion, from oospores of the general appearance represented in *fig. 90*. During fusion the whole nucleus becomes more darkly stained with gentian-violet.

FIG. 41. Cœnocentrum with globule at its center, female nucleus near by, ordinary vacuoles of the oosphere near the margin.

PLATE XII.

Magnification in all figures 1500 diameters.

FIG. 42. A portion of mycelium, showing nuclei with prominent nucleoli.

FIG. 43. Nuclei and cytoplasm flowing into a developing oogonium, nuclei and vacuoles elongated and angular, nuclei too darkly stained to show structure.

FIG. 44. The septum below the oogonium, a portion of mycelium and posterior end of oogonium, oogonial nuclei assuming the spirem stage, mycelial nuclei still in resting condition with prominent nucleoli but enlarged.

FIG. 45. Oogonium and antheridium, nuclei of both in the spirem stage.

FIG. 46. Shows location of oil drops in an oogonium of the condition presented in *fig. 45*. They were all drawn at one focus; a slight change of focus would have brought vastly more into view.

FIG. 47. Showing adhesion of the oogonial *Hautschicht* to its wall in the neighborhood of the antheridium, nuclei overstained.

FIG. 48. Adhesion as in *fig. 47*. Oogonial wall partly and irregularly corroded away on the side toward the oogonium.

FIGS. 49–55. Stages in the perforation of the wall preparatory to the entrance of the antheridial tube.

FIG. 49. Optical section of papilla, wall partly corroded away and bulging toward the antheridium. The dense protoplasm represented in black was stained a deep red by the safranin.

FIG. 50. Sectional view of a condition slightly older than *fig. 49*. The shaded portion of the separating wall took the stain differently from the rest, and was apparently in the last stages of dissolution.

FIG. 51. A papilla of different shape in a stage similar to the last.

FIG. 52. Optical section, stain as in *fig. 49*.

FIG. 53. A papilla becoming bubble-like, walls very thin, slightly shrunken as though due to imperfect killing, watery vacuoles apparent, their contents staining homogeneously with the gentian violet.

FIG. 54. Bubble-like papilla expanding irregularly in all directions, contents highly vacuolate, wall extremely thin.

FIG. 55. Wall almost perforated, but showing no marked bulging in either direction, *o*, oogonial, *a*, antheridial side.

FIGS. 56, 57. Young antheridial tubes with a cellulose wall and surrounded by a dense sheath of the protoplasm of the oogonium.

FIG. 58. Protoplasm beginning to collect in masses, nuclei approaching metaphase, some shown in polar view (preparation from material fixed in Flemming's agent and stained by hæmatoxylin).

FIG. 59. An intercalary oogonium, slightly older condition than *fig. 58*, cytoplasm distinctly in masses, nuclei in early prophase, antheridial tube just entering bearing no nuclei, a haustorium at extreme right.

PLATE XIII.

Magnification in *figs. 60, 61, 62, 63, 64, 65, 68, 69, 70, 72,* 1500 diameters; in *figs. 66, 67, 71,* 3300 diameters; in *fig. 73,* 2200 diameters.

FIG. 60. Nuclei in metaphase, protoplasm massed in a few centers, spindles very clear and brilliant (stain hematoxylin from material fixed in Flemming's agent).

FIG. 61. Nuclei in late prophase, the protoplasmic masses coalesced to form one, vacuoles mark the juncture last made, a few nuclei not yet floated out.

FIG. 62. Nuclei approaching metaphase, spindles much elongated, all not yet extruded from the central region, mitosis in the antheridium, antheridial tube shown at its typical position for this stage.

FIG. 63. Diagram of disposition of oil drops in an oogonium of the condition shown in *fig. 65* (zonation).

FIG. 64. Nuclei nearly at metaphase, zonation almost complete, oil-like drop to the right in ooplasm, antheridial tube present showing no nuclei.

FIG. 65. Zonation: nuclei near metaphase, ooplasm sharply differentiated, many spindles lying directly across the boundary between ooplasm and periplasm (stained by hæmatoxylin from Flemming material). See also *fig. 64.*

FIG. 66. Shows spindle in metaphase lying across the film between ooplasm and periplasm.

FIG. 67. Nucleus in anaphase directly across the boundary film of the ooplasm, also half of a late anaphase cut diagonally.

FIGS. 68, 69. Consecutive sections of an oogonium just after the division of the nuclei, showing the position and shape of the antheridial tube. *Fig. 69* shows the cœnocentrum which had just passed its maximum development (see *fig. 71*).

FIG. 70. Antheridial tube and differentiating oosphere, oosphere nuclei in mitosis. *Fig. 74* was taken from an adjacent section of the same oogonium and shows the cœnocentrum.

FIG. 71. Completely developed cœnocentrum, the central globule surrounded by three regions of differentiated protoplasm. From a stage of zonation where the nuclei were in anaphase (as in *fig. 67*) and the daughter nuclei were about to pass into the ooplasm.

FIG. 72. Diagram of distribution of oil at the stage shown in *fig. 70.*

FIG. 73. Antheridium and tube of the age shown in *fig. 70*, showing multinucleate contents; *l*, film; ♀, one of the female nuclei; *p*, periplasm; *x, x*, nuclei, represented also in *Plate XI, figs. 31, 32.*

PLATE XIV.

Magnification in *figs. 74, 80, 82, 87, 88*, 1500 diameters; *fig. 76*, 2200 diameters; *figs. 75, 77, 78, 84, 85, 86*, 3300 diameters.

FIG. 74. Cœnocentrum and differentiated oosphere with dividing nuclei. The broken empty portion is where the protoplasm shrunk away from the antheridial tube. Section adjacent to that shown in *fig. 70*.

FIG. 75. Cœnocentrum, in an oogonium, at anaphase period of zonation, consisting of three small globules evidently fusing, surrounded by a region of denser protoplasm, granules resembling small oil drops scattered through the ooplasm.

FIG. 76. Similar to *fig. 73* but somewhat older, antheridial tube showing many nuclei, slightly torn near tip, antheridium becoming vacuolate; *p*, periplasm; *b*, film; ♀, female nucleus.

FIG. 76 *a*. Portion of the tip of the same tube, found in an adjacent section.

FIG. 77. View of the end of an unopened antheridial tube, wall not apparent, sperms very numerous and crowded, each showing a dark nucleolus, ooplasm slightly shrunken away from the tube.

FIG. 78. Section near the base of the same antheridial tube, showing very thick wall in contrast with the extremely thin film covering the apex.

FIG. 79. Diagram to show position of preceding sections. *Fig. 77* was from a section just above the line *aa*; *fig. 78* from one just below the line *bb*. One intermediate section was not drawn.

FIGS. 80, 80*a*. Adjacent and approximately longitudinal sections of the opening antheridial tube of the same oogonium, showing the primitive wall and the increased vacuolation of the ooplasm which frequently shrinks away from the primitive wall.

FIG. 81. Diagram of the distribution of oil in an oogonium of the age shown in *fig. 80*.

FIG. 82. Antheridial tube discharging sperms, antheridium shown above, primitive wall very young, ooplasm becoming vacuolate, antheridial tube cut slightly oblique so that its base is in an adjacent section.

FIG. 83. Diagram to show relation of sections presented in *figs. 84, 85, 86*: *fig. 84* was cut from above the line *aa*, and tangential to the tip of the opening tube; *fig. 85* from between the lines; *fig. 86* from just below the line *bb*.

FIG. 84 (see *fig. 83*). Sperm nuclei leaving the antheridial tube and approaching the female nuclei.

FIG. 85 (see *fig. 83*). Mass of sperms escaping from tube. The tube may be traced to the left as a mass of darkly stained structureless protoplasm.

The sperms in a mass appear dark but individually are hyaline except at anterior end which bears the nucleolus. See also *fig. 33, Plate XI.*

FIG. 86 (see *fig 83*). The base of the antheridial tube filled with dark staining cytoplasm and few nuclei.

FIG. 87. Just after discharge from antheridial tube, periplasm as in *fig. 82*, several small masses of nuclei apparently both male and female surrounded by denser cytoplasm (these masses seem to arise by the breaking apart of the contents of the antheridial tube and soon disappear), primitive wall well developed, antheridium above, ooplasm coarsely and irregularly vacuolate.

FIG. 88. Nuclei fusing in pairs, primitive wall distinctly thickened. See *Plate XI, figs. 36–40.*

PLATE XV.

All figures magnified 1500 diameters.

FIG. 89. Protoplasm collecting in dense network toward the center of the oospore, leaving light peripheral strands where the endospore is soon to appear.

FIG. 90. Shows the remains of the antheridial tube in the periplasm, with no trace of its former presence in the ooplasm. The oospore is of the age shown in *fig. 88.*

FIG. 91. Primitive wall mature, exospore forming, now consisting of a porous semi-transparent mass with imbedded disks which are to form the ridges, vacuoles in oospore filled with gelatinous substance, nuclei of protoplasm overstained.

FIG. 92. Somewhat younger than the last figure, showing structure of exospore more clearly, presents edge view and also a fragment bent back and giving a surface view, gelatinous substance in vacuoles.

FIG. 93. Exospore nearly formed, primary endospore complete, vacuoles still containing gelatinous substance.

FIG. 94. Rudimentary secondary endospore, gelatinous substance in vacuoles.

FIG. 95. Oil forming in oospore.

FIG. 96. Spore walls complete, including double endospore, vacuoles with no gelatinous substance, oil accumulating in large drops on the endospore walls.

FIG. 97. Winter conditions of exospore, the ridges higher than in previous stages, large central oil-like mass, nuclei in sporoplasm. Section not directly through middle so that the endospore appears thicker than it really is.

FIG. 98. Exterior of ripe oospore.

NOTES ON THE DEVELOPMENT OF THE HOLDFASTS OF CERTAIN FLORIDEÆ.

CARRIE M. DERICK.

(WITH PLATES XXI–XXIII AND FIVE TEXT-FIGURES)

WITH the exception of passing references in various works, two articles, the one by Borge (**1**), the other by Strömfelt (**8**), include, I believe, all that has been written upon the holdfasts of the algæ. The former deals with a few members of the Chlorophyceæ; the latter is very comprehensive, but it is without illustrations and gives no specific details. Therefore, the study of the development of the holdfasts of some nearly related species of the Rhodophyceæ has seemed advisable.

The observations described in this paper were made at the Marine Biological Laboratory, Woods Hole, Mass., during the summers of 1896 and 1897, and the work was finished in the Botanical Laboratory of McGill College.

Cultures of the spores of several species were made under various conditions. Ordinary glass object-slides were placed in flat porcelain dishes, either white or painted black. The vessels were filled with filtered sea-water and in them were laid plants bearing ripe spores. The spores usually sowed themselves in twenty-four hours, in which case the plants were removed. Some of the dishes were fed by a gentle stream of running water, others were disturbed only three times a day, when the water was drawn off by a siphon and replaced by filtered sea-water. The latter method proved much the better of the two.

The color of the background had no effect upon the development of the spores, nor were the plantlets heliotropic. Cultures kept in a shaded place flourished best, even a short exposure to direct sunlight killing plantlets. It is to be regretted that no record of variations in the temperature and the density of the water was kept. Oltmanns (**6**) has conclusively shown that such

variations are most important factors in the life and distribution of marine algæ, but a comparison of many cultures of the same species indicates that differences in the conditions which prevailed in the laboratory affected neither the form nor the order of development of the plantlet. It was difficult to keep the young plants healthy for more than three or four weeks; and during a few days of intense heat, in August 1896, all ceased to grow, were attacked by bacteria, and finally died.

Both carpospores and tetraspores were germinated and most closely resembled one another in their development. In some cases, however, tetraspores attached themselves to the substratum less readily than carpospores. This is regarded by Brannon (2) as an adaptation to the immediate distribution of the species.

Every day, slides upon which spores were growing were examined and drawings of living plantlets were made. Permanent mounts for comparative study were prepared at regular intervals and mature holdfasts were preserved in alcohol or in 5 per cent. formalin in sea water.

The species selected for investigation belonged to the Rhodymeniales, with the exception of one member of the Rhodophyllidaceæ, *Rhabdonia tenera* J. Ag. The carpospores of this alga attach themselves firmly to the slides in nine hours; a very delicate outer layer, probably of mucilage, may be observed, but can hardly be distinguished from the cell-wall (*Pl. XXI, fig. 1*). In a few cases, an irregular layer of a coarsely granular substance surrounded the plantlets, and in one, a thick mucilaginous disk was developed at the base; these appearances were most exceptional and were doubtless due to slightly abnormal conditions (*Pl. XXI, figs. 7, 8*). After attaching themselves, the spores immediately enter upon a segmentation stage, and within twenty-two hours two divisions are made. The first separates the spore by means of a vertical wall into two equal cells (*Pl. XXI, figs. 2, 3*). Three and four-celled stages result from the successive division of the two primary cells in vertical planes at right angles to the first wall; other cells are cut off from these by oblique walls, and thus an irregular spherical mass is formed.

In about thirteen days differentiation begins. Four basal cells elongate to form the primary root-cells, the position of which bears no definite relation to the direction of the supply of light (*Pl. XXI, figs. 7, 8*). Occasionally only one or two primary rhizoids are thus formed (*Pl. XXI, figs. 9, 10, 11*). Unfortunately, the plantlets died at this stage, and only by analogy could the subsequent history of the holdfasts be determined. However, the close resemblance between the primary root-cells and mature holdfasts of Rhabdonia and of the two species to be considered next justifies the assumption that the intermediate stages closely agree. It is interesting to note that, according to Osterhout (**7**), the earliest divisions in the tetraspores which give rise to proliferations do not succeed one another in the definite order just described, but the spores divide "by means of oblique walls which do not occur in regular succession."

Very similar to that of Rhabdonia is the early history of *Lomentaria uncinata* Menegh. and of *Champia parvula* Harv. The carpospores of Lomentaria, after secreting a wall, attach themselves to the substratum by a very thin mucilaginous secretion (*Pl. XXI, fig. 12*), which sometimes persists after the first rhizoids have been formed (*Pl. XXI, fig. 15*). The segmentation proceeds rapidly, but primary root-cells do not arise until a later date than in Rhabdonia (*Pl. XXI, figs. 13, 14*). The four basal root-cells, dividing by horizontal walls, become short, closely-appressed filaments, which soon branch pseudodichotomously (*Pl. XXI, figs. 15, 16*) and form a discoid holdfast. Strömfelt (**8**) regards the branching of the rhizoidal filaments as dichotomous and says that the increase in circumference of the mature holdfast is due almost entirely to marginal growth. Vegetative reproduction may take place not only by the mechanical separation of the various upright branches, which spring adventitiously from the surface of the holdfast (*Pl. XXI, fig. 22*), but by means of stolons, which are sent out in various directions and form secondary holdfasts (*Pl. XXI, fig. 21*).

Davis's account (**4**) of the plantlets of *Champia parvula*,

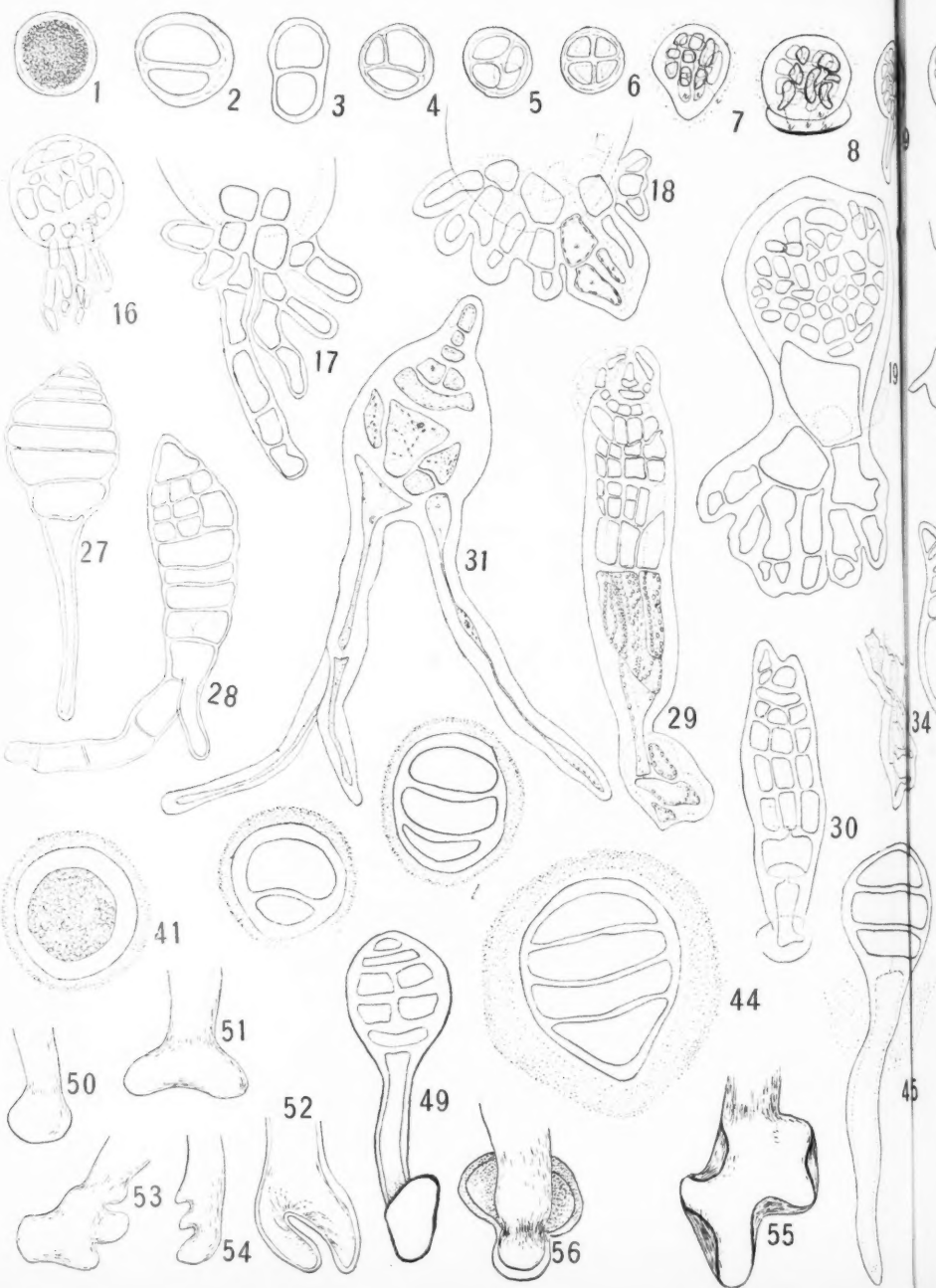
developing under natural conditions, accurately describes those grown in the laboratory. A somewhat spherical mass composed of sixteen cells results from the segmentation of the spore, then the first indication of a permanent holdfast appears as a slight projection of each of the four basal cells. The primary root-cells, dividing at right angles to their longest axis, form two-celled filaments, which branch monopodially and give rise to a broad spreading holdfast. In section the mature holdfast appears parenchymatous (*Pl. XXI, figs. 17, 18*), but it is often possible to distinguish the component filaments (*Pl. XXI, fig. 20*). Exceptional plantlets produce one instead of four primary root-cells, but the later stages conform to the type (*Pl. XXI, fig. 19*). In all cases the cells of the holdfast are paler than those of the frond, and the chromatophores of young specimens are in close contact with the walls.

From the foregoing it will be seen that Rhabdonia, Lomentaria, and Champia agree (*a*) in passing through a segmentation stage, resulting in a somewhat spherical mass of cells, (*b*) in the elongation of four basal cells, and (*c*) in the subsequent development of four primary rhizoids, which branch repeatedly and finally form a large discoid holdfast, composed of pseudo-parenchymatous tissue.

In marked contrast are several members of the Rhodomelaceæ. The spores of *Chondria tenuissima* (Good. et Wood.) C. Ag. and of *Chondria dasyphila* Ag. germinate very readily. The early divisions of the spores and the history of the development of the rhizoids are alike in the two species. The spores, which are large and have coarsely granular contents, quickly and firmly attach themselves to the substratum, doubtless by means of a thin and uniform layer of mucilage, though no secretion distinct from the cell-wall is perceptible (*Pl. XXI, fig. 23*). They soon divide into two unequal cells separated by a slightly concave wall; divisions parallel to the first follow (*Pl. XXI, fig. 24*), and the basal cell of the resulting filament elongates into the primary rhizoid (*Pl. XXI, figs. 25, 27*). Sometimes the basal cell seems to branch dichotomously; but, as the branches do not

arise simultaneously nor are they separated by a wall parallel to the longer axis of the basal cell, it is evident that the branching of the filaments is strictly monopodial (*Pl. XXI, figs. 26, 32, 35*). The upper cells of the plantlet soon cut off pericentral cells, and at the same period the first rhizoid divides repeatedly so as to form a multicellular, monosiphonous filament (*Pl. XXI, figs. 28, 35*). Secondary rhizoids are next developed, either as outgrowths from the primary root-cell or from a pericentral cell immediately above the basal cell (*Pl. XXI, fig. 31*). Long slender rhizoids may be formed before a clasping-disk arises, but, both in plantlets developing in the laboratory (*Pl. XXI, figs. 29, 33, 36*) and in those growing in a state of nature (*Pl. XXI, figs. 30, 38, 39, 40*), the primary rhizoid generally remains very short and by means of oblique walls produces discoid holdfasts at the tip. The size and efficiency of this holdfast are increased by means of free secondary rhizoids (*Pl. XXI, fig. 33*) or by intracuticular filaments (*Pl. XXI, fig. 34*), both of which have their origin in pericentral cells near the base of the plantlet. The secondary rhizoids develop in the same manner as the primary and combine with them to form a large, irregular, discoid holdfast, in which it is possible to distinguish few of the component filaments (*Pl. XXI, fig. 37*). The mature holdfast, though adhering closely to its host, does not penetrate it, but a cutinization of the cortical layers often results from the contact. As in Lomentaria, etc., the large holdfast gives rise to several adventitious branches; and great powers of vegetative reproduction are implied by the stores of floridean starch with which the cells are often charged. The chromatophores are closely aggregated in the peripheral protoplasm, especially next to the inner radial and the lateral walls, and often indicate the plane in which a wall will soon be formed. They are large and discoid, thus resembling those of the cortical cells of the frond rather than the anastomosing filamentous chromatophores of the central cells.

Very different from the short, multicellular, primary rhizoids of the Chondrieæ are the primary holdfasts of the Polysiphonieæ. The form taken as a type of the latter group is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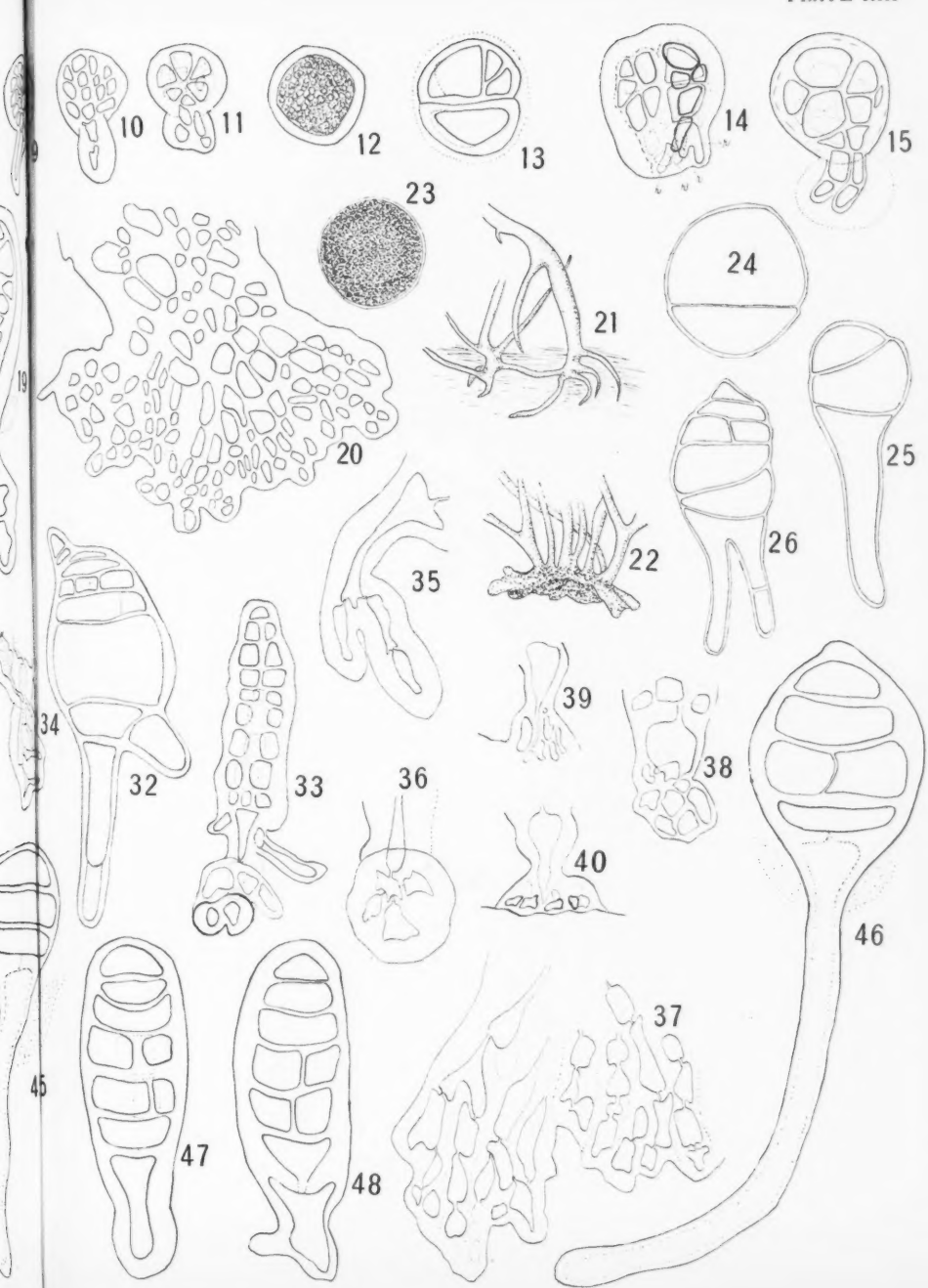
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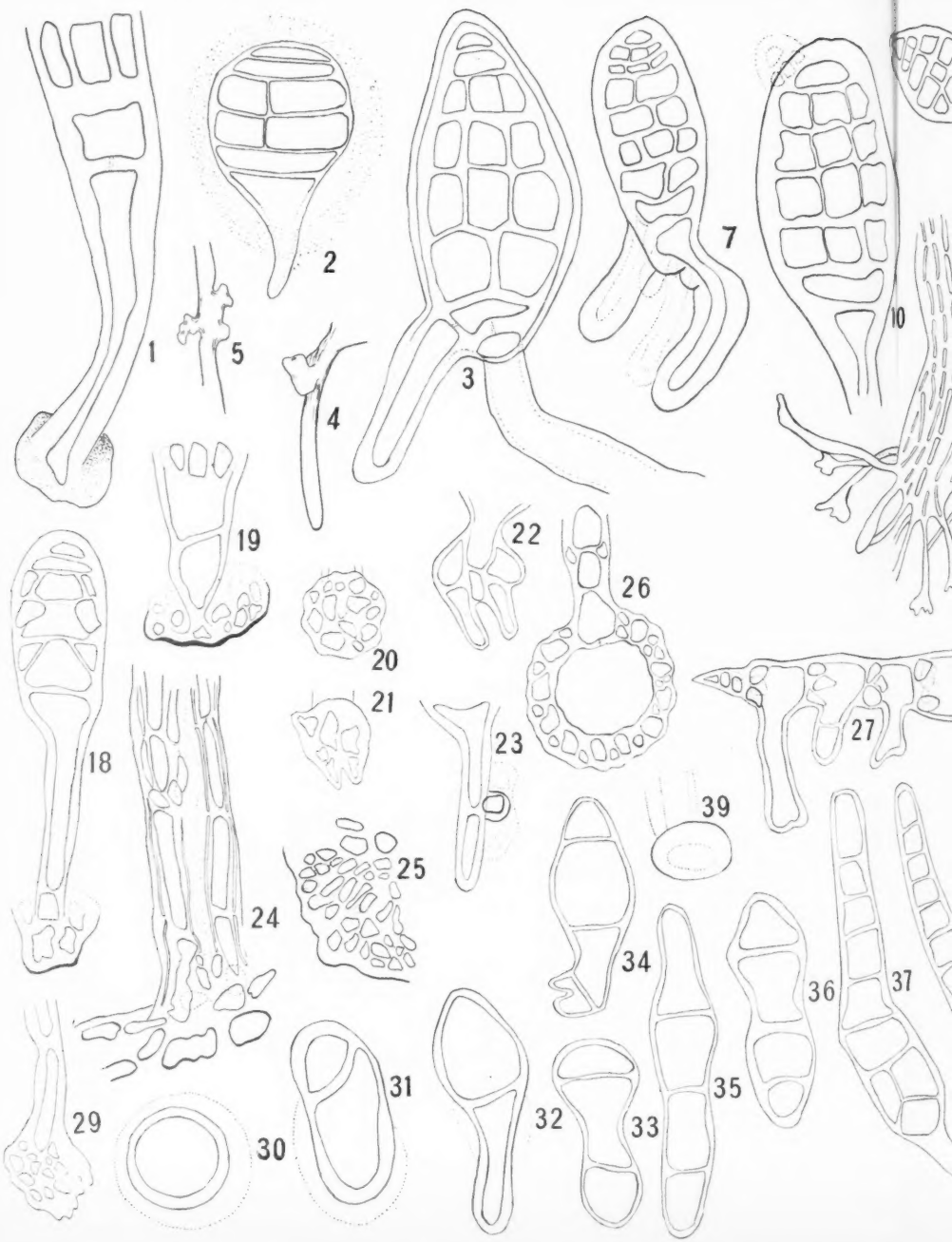
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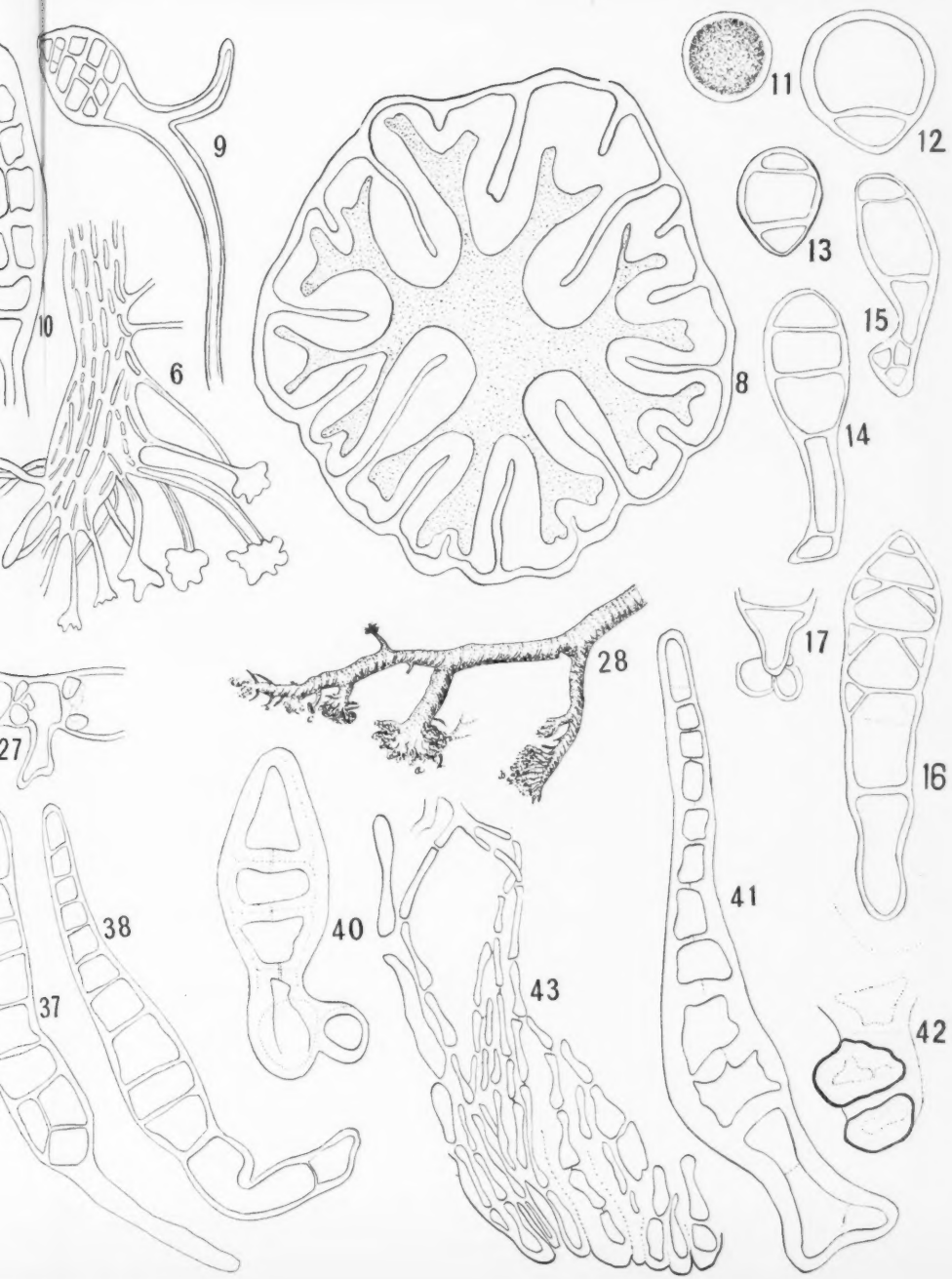
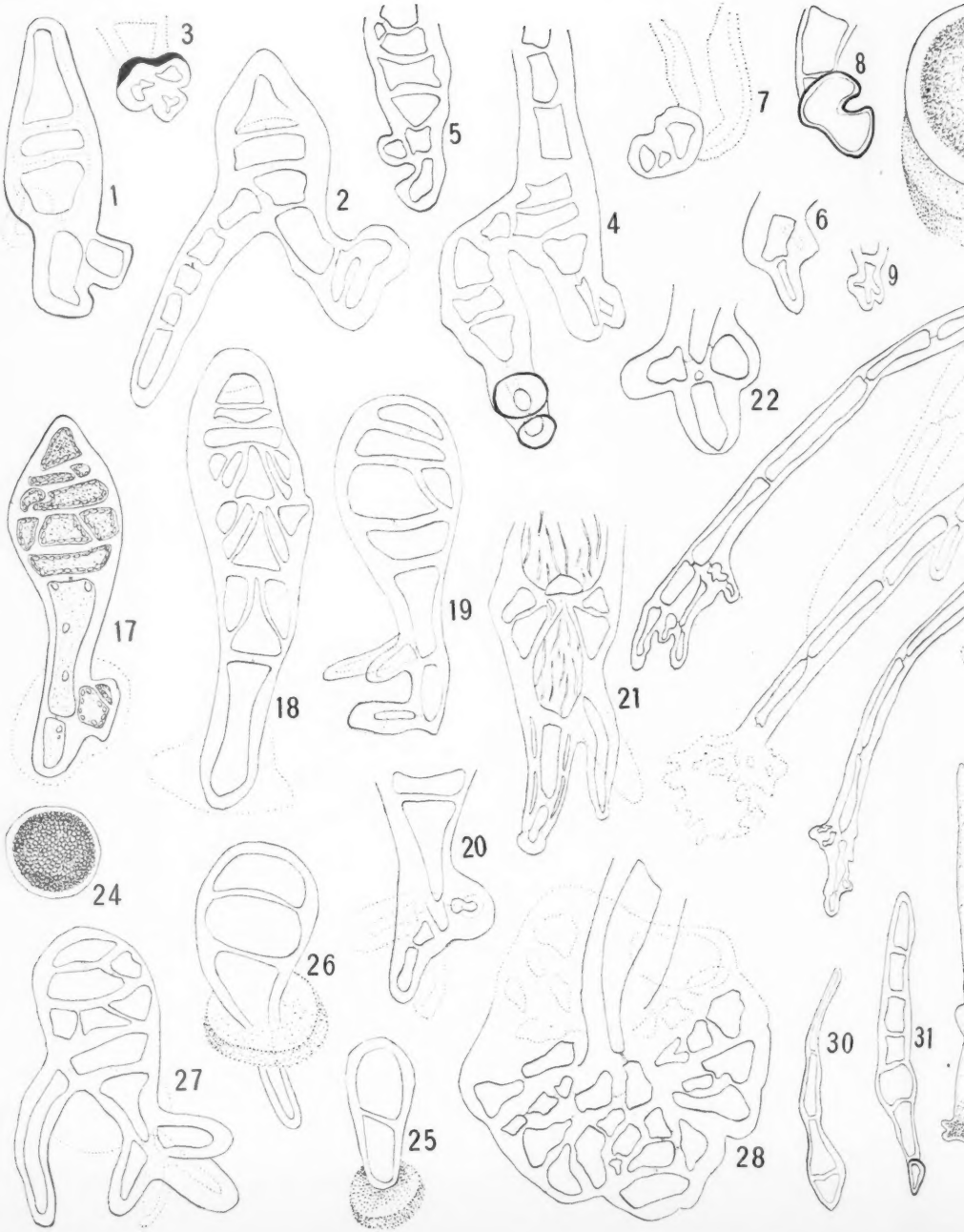


FASTS OF RHODOPHYCEÆ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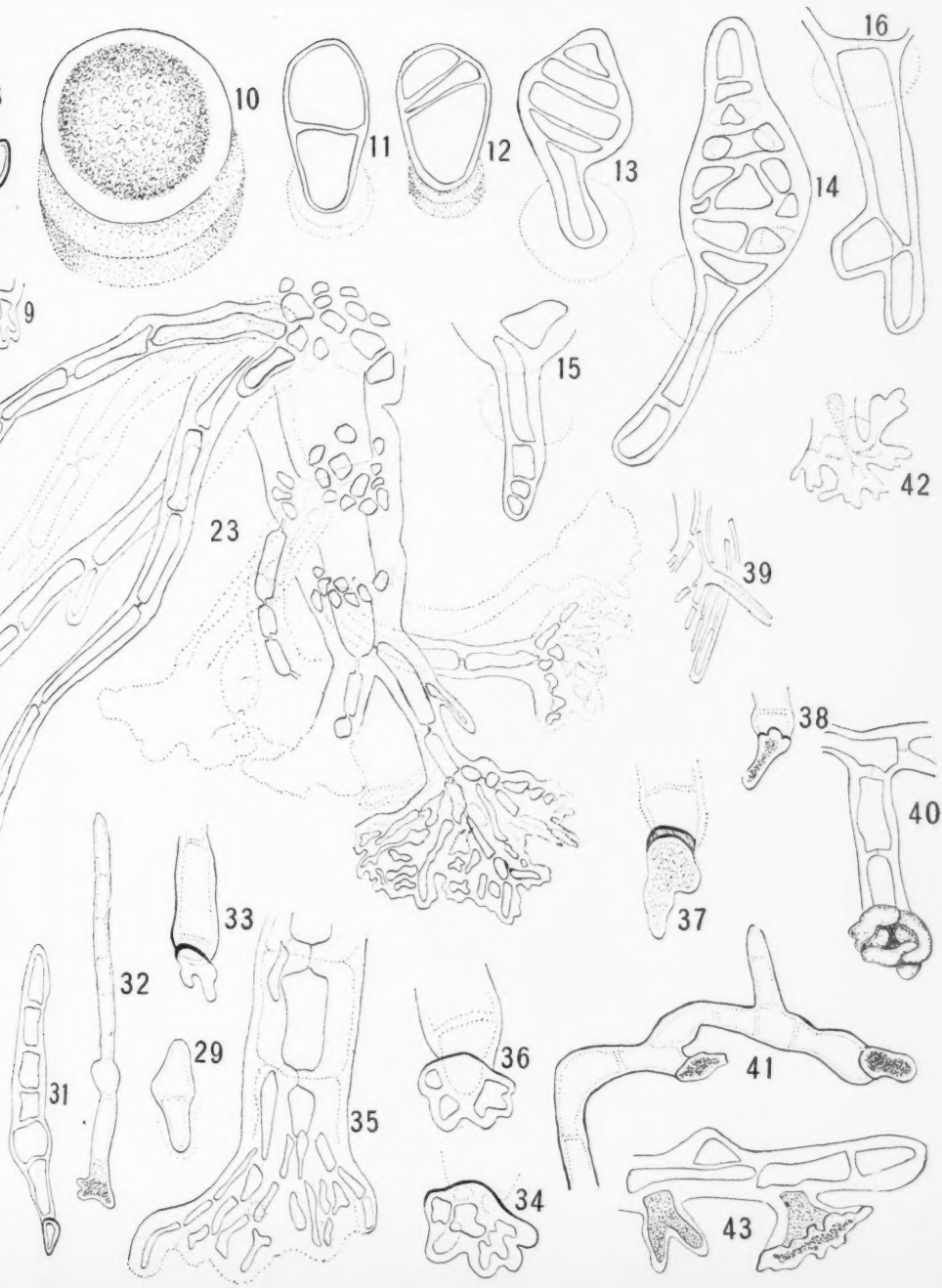

ASTS OF RHODOPHYCEÆ

Polysiphonia violacea (Roth) Grev. In a few hours after they are sown, both carpospores and tetraspores attach themselves to the substratum by a coarsely granular, mucilaginous secretion, which completely covers the spore (*Pl. XXI, fig. 41*). In optical section this envelope appears densely granular at the margin, while a clear amorphous area intervenes between the outer layer and the developing plantlet (*Pl. XXI, fig. 44*). The spore divides into two unequal cells, of which the smaller soon becomes slightly pointed and finally grows into the primary root-cell (*Pl. XXI, fig. 42*). Divisions parallel to the first ensue (*Pl. XXI, figs. 43–45*), and the basal-cell elongates so as to form the first rhizoid piercing the mucilaginous sheath, which finally disintegrates and disappears. A six-celled stage is often reached before divisions in planes at an angle to the first occur. Generally, segmentation continues for some time and the siphons are clearly marked off from the central axis before a second rhizoid arises. As in Chondria, this has its origin in an unsegmented cell adjacent to the primary root-cell. The former differs from the latter only in its brighter color and denser cell-contents; and, remaining undivided, it forms a component part of the holdfast (*Pl. XXI, fig. 50*). The protoplasmic connections between these cells are obvious, but they are difficult to trace between the other cells of the plantlet (*Pl. XXI, figs. 45, 47*). When three or four weeks old the young plant develops several rhizoids springing either from the primary or secondary root-cell (*Pl. XXII, fig. 7*). Occasionally, however, the segmentation stage of the spore ends and the growth of the frond begins before multiplication of the rhizoids takes place (*Pl. XXII, fig. 10*). At the base of the frond other rhizoids are sent out by corticating cells and are separated from these by a wall, a protoplasmic connection being maintained. No intracuticular filaments are developed and the independence of the rhizoidal constituents of the mature holdfast is practically preserved (*Pl. XXII, fig. 6*). In addition to the rhizoids near the base of the plant, any corticating cell of a procumbent branch may produce a secondary holdfast and thus assist in the extension of the colony. As Strömfelt (8) noted,

all the rhizoids are unicellular and unbranched; and, although an apparent tendency to branch may be observed occasionally, the lobes are not separated from the main portion by a wall, even the protoplasmic contents being undivided (*Pl. XXII, fig. 9*). All the rhizoids eventually develop terminal clasping-disks. The first indication of such a structure may appear in plantlets four days old, but, as a rule, the primary rhizoids do not undergo modification until several days later. The disks begin as a simple enlargement of the tip of the rhizoid (*Pl. XXI, figs. 48–50; XXII, fig. 1*), become deeply lobed, and assume a very irregular outline (*Pl. XXI, figs. 52–56*). The cell-contents of the rhizoid extend into the lobes, but no division takes place (*Pl. XXII, fig. 8*). Great variations in the length attained by the primary rhizoids occur both in plants grown under natural conditions and in laboratory cultures (*Pl. XXI, figs. 46, 48; XXII, fig. 1*). The cause of such variations has not been determined, but it is probable that contact irritation may be the most important factor in the formation of the disks. This view is supported by the fact that disks are sometimes produced on the sides of rhizoids when these come in contact with a firm substance (*Pl. XXII, figs. 4, 5*). The length of the secondary rhizoids depends upon the distance of the parent cells from the substratum, and as soon as contact is established broad clasping-disks are formed, which mechanically cohering with one another and with the primary disk produce a very strong holdfast. The rhizoids are paler in color than the rest of the plantlet, having less dense contents and fewer chromatophores.

The rhizoids of *Polysiphonia violacea* never penetrate the host-plant; but at the point of contact the surface of the latter is often dark brown and cutinized, while the outer cortical cells are destitute of chromatophores. But incipient parasitism occurs in *Polysiphonia fastigiata* Grev., growing on *Ascophyllum nodosum* Stack. Gibson (**5**), in writing of the histology of this species, noticed that "the attachment of the epiphyte to Ascophyllum is very intimate. Root-filaments given off from the base of the frond penetrate deeply into the tissue of the host, and wander

among the cortical cells and medullary hyphæ. The root-filaments have very thick cell-walls and central cells only, these being much elongated." The ends of the rhizoids are swollen and in close contact with the cells of the host (*text figs. 4, 5*, p. 256), but no haustoria penetrate the walls of the latter. In one instance a unique variation occurred. A few intracuticular filaments, descending from the corticating cells of the Polysiphonia, ran parallel to the main axis of the rhizoid throughout its length. The host suffers no serious injury, only a depression and cutinization of the surface with a very slight disorganization of the cortical cells at the point of penetration. Though the association of the two plants does not justify the assumption of complete parasitism, the symbiotic relation existing between them is much more intimate than that observed between Ascophyllum and any of the truly epiphytic algæ. According to Brebner (**3**), a similar relation exists between *Dumontia filiformis* and its host, *Fucus serratus*.

Dasya elegans (Martens) C. Ag. was the third species of the Rhodomelaceæ examined. The spores attach themselves by a mucilaginous secretion much less definite in form and less persistent than in *Polysiphonia violacea* (*Pl. XXII, fig. 30*). The spore elongates before the division takes place, and in many instances the very young plantlet assumes an hour-glass shape, occasionally with a delicate mucilaginous secretion at either end. The first walls are parallel to one another, forming a long filamentous body, of which one terminal cell becomes the apical cell of the frond, the other the primary root-cell (*Pl. XXII, figs. 31, 32, 33, 35, 36*). Twelve or more parallel divisions may occur before the basal cell elongates and forms a rhizoid terminating in a disk; but such a modification may appear at an earlier period (*Pl. XXII, fig. 34*). The multicellular disks, which arise sooner or later, are like those of Chondria. The root-cell or the end of a rhizoid broadens and becomes slightly lobed; oblique walls cut off the lower corners of the cell; division is continued and a multicellular disk with a mucilaginous margin results (*Pl. XXII, figs. 39–41; XXIII, figs. 2, 3, 7, 8, 9*). The primary root-

cell often branches, each portion giving rise to a disk (*Pl. XXII, fig. 42; XXIII, fig. 4*). Although the primary rhizoid usually remains short, in some instances it attains considerable length before undergoing division or forming a disk (*Pl. XXII, figs. 37, 38*). While these changes are taking place, the cell adjacent to the basal cell sends out rhizoids similar to those arising from the primary root-cell (*Pl. XXIII, figs. 1, 5, 6*). These various root-filaments combine to form the primary holdfast, which is afterwards strengthened by multicellular branching rhizoids, springing from the basal corticating cells of the frond. The course of the filaments may be traced for some distance in the holdfast, but it is difficult to distinguish between those cells which have their origin in the primary disk and those which are derived from the corticating filaments. The difficulty in determining the relationship of the parts is increased by secondary lateral connections, which are developed between the corticating cells (*Pl. XXII, fig. 43*). The marginal cells of the mature holdfast are larger and broader in proportion to their length than the corticating cells of the frond, and have denser cell contents, but the chromatophores of both are separate disks, while those of the central siphon are the anastomosing filaments characteristic of many of the Rhodomelaceæ. A creeping tendency may be exhibited at an early age, very young plantlets sometimes developing two distinct holdfasts of almost equal importance (*Pl. XXIII, fig. 4*). As in the other species described, many branches arise from the massive rounded holdfast, probably springing adventitiously from the surface of the latter.

A comparison of the three species of the Rhodomelaceæ described will show that they agree in forming a primary root-cell, which elongates into a rhizoid terminating in a clasping disk; and in developing secondary rhizoids, which are sent out by the root-cell, the cell adjacent to it, and the cortical cells at the base of the frond. But, while the rhizoids of Polysiphonia are unicellular, unbranched, and free, those of Dasya and Chondria are multicellular, branched, and aggregated into a compact cell-mass, which in section resembles parenchymatous tissue.

The species remaining for consideration belong to the Ceramiaceæ. Cultures of *Spermothamnion Turneri* Aresch. were unsuccessful, only one healthy plantlet having been obtained. It developed two small disks, the one a terminal primary holdfast, the other a secondary structure arising from one of the middle cells of the filament (*Pl. XXIII, fig. 41*). As Strömfelt has pointed out, the mature rhizoids are short, unicellular, unbranched organs, terminating in a lobed disk in which delicate threads of protoplasm can be traced (*Pl. XXIII, figs. 42, 43*). The rhizoids are especially abundant near the base of the plants, but, as is well known, any cell of a procumbent branch may give rise to these simple bodies. Now and then, an ordinary branch of the frond produces at its apex a much-lobed twisted disk, which closely embraces a neighboring branch as a tendril would a support (*Pl. XXIII, fig. 40*).

Very few spores of *Griffithsia Bornetiana* Farlow germinated, and the resulting plantlets were short-lived. It is, therefore, impossible to describe each step in the development of the holdfast. Two unequal cells arise from the first division (*text fig. 1*), a monosiphonous filament composed of rather globose cells is formed, the basal cell of which elongates and becomes the root-cell (*text fig. 2*). The structure of mature holdfasts would lead one to suppose that the primary root-cell divides repeatedly, forming a broad spreading mass of large-celled pseudo-parenchymatous tissue. The holdfasts of a young plant attached to a small piece of bone (*text fig. 3*) and of older plants growing on *Zostera marina* L. differed only in size, that of the latter being very large with an abundance of adventitious branches arising from its margin. Strömfelt (**8**) places the genus Griffithsia with Ceramium and Callithamnion in a group distinguished by branching rhizoids; but, though many mature specimens of *Griffithsia Bornetiana* were examined, no such secondary formations were seen. The cells of the holdfasts are brilliantly colored and have very dense granular contents, probably due to a large supply of reserve food-material.

A closely allied genus, Callithamnion, differs greatly from

Griffithsia in the form and history of the holdfast. Though the spores of *Callithamnion Borreri* Ag. developed in the laboratory with difficulty, cultures sufficient to illustrate the order of development succeeded. After attaching themselves to the slide by an almost imperceptible secretion, the spores elongate and become pointed at both ends. The first division is parallel to the shorter axis (*Pl. XXIII, fig. 29*), and by subsequent partition a

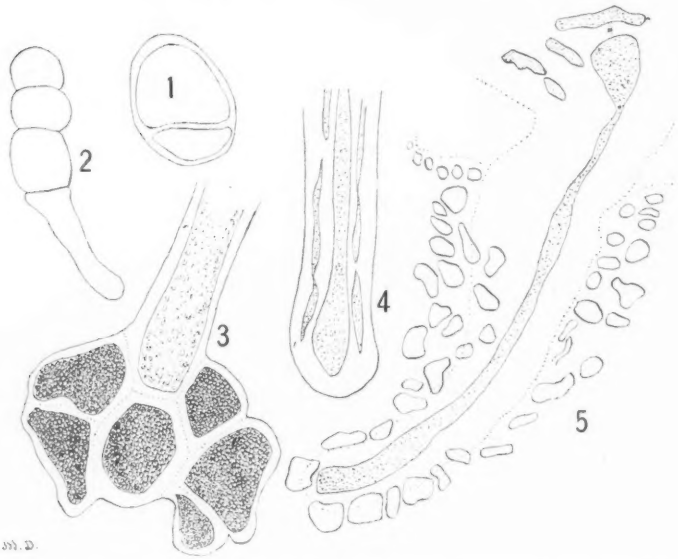

FIG. 1. *Griffithsia Bornetiana* Farlow, germinating tetraspore 9 days after sowing. × 333.

FIG. 2. *G. Bornetiana*, plantlet 9 days old. × 213.

FIG. 3. *G. Bornetiana*, holdfast of small plant growing on bone. × 53.

FIGS. 4, 5. *Polysiphonia fastigiata* Greville, growing on *Ascophyllum nodosum* Stack.; in *fig. 5* the cells of *P. fastigiata* are shaded in, those of Ascophyllum are merely outlined. × 213.

monosiphonous filament is formed. The smaller of the two terminal cells is the primary root-cell (*Pl. XXIII, fig. 30*). Judging from one set of cultures, the first cell of the holdfast, which has a very thick mucilaginous wall, is cut off from the swollen

extremity of the root-cell and separated from it by a wall (*Pl. XXIII, figs. 31–33, 37, 38*). A multicellular holdfast results from the division and branching of the primary root-cell and of the oldest cell of the disk (*Pl. XXIII, figs. 34, 36*), and is further strengthened by a few corticating rhizoidal filaments. In mature *Callithamnion Baileyi* Harv. the intracuticular rhizoids are more numerous. They arise from the lower angles of the central cells or from the basal cells of the branches. Thence they descend through the walls of the monosiphonous frond to the holdfast, where they branch freely and spread out in various directions, forming, with the filaments arising from the cells of the primary disk, a flat circular holdfast (*Pl. XXIII, figs. 35, 39*).

The carpospores of *Spyridia filamentosa* (Wulf.) Harv. germinate very readily. The mucilaginous secretion, by which the spores are first fastened to the substratum, can hardly be distinguished from the wall of the spore (*Pl. XXII, fig. 11*). The spore first forms two unequal cells, the smaller of which becomes the primary root-cell, the larger divides by parallel walls so as to form a short filament (*Pl. XXII, figs. 12–14*). As a rule, no long primary rhizoid is formed, but occasional exceptions are found (*Pl. XXII, fig. 18*). Though variations may occur (*Pl. XXII, fig. 15*), the first corticating cells are usually cut off from the upper angles of the central cells before the formation of the discoidal holdfast begins (*Pl. XXII, fig. 16*). Sooner or later, however, the primary root-cell divides in several planes parallel to the longer axis of the spore, and thus produces a flat multicellular disk, the cells of which are separated by walls (*Pl. XXII, figs. 15, 17, 19, 20, 21*). At first the primary disk is but slightly lobed, but the cells soon give rise to short filamentous outgrowths, which branch pseudo-dichotomously (*Pl. XXII, figs. 21, 22*). Rarely a lateral disk springs from the primary root-cell, which is then prolonged into a filament (*Pl. XXII, fig. 23*). The cells of the primary holdfast continue to divide, and with them are combined rhizoidal filaments, which have their origin in the corticating cells of the lower nodes of the frond and grow through the cell-walls to the substratum (*Pl. XXII, figs. 24, 25*). Free filamentous

outgrowths of the larger cortical cells develop disks and enter into close mechanical union with the main holdfast, adding greatly to its efficiency. The secondary rhizoids thus formed are destitute of cortications (*Pl. XXII, fig. 29*) and are easily distinguished from those ordinary branches which, coming in contact with the substratum, develop holdfasts (*Pl. XXII, figs. 26, 28a*). Spyridia creeps not only by means of such branches but by the aid of masses of uncorticated hair-like rhizoids, which may be formed at any point (*Pl. XXII, fig. 28b*). One curious instance was noted of short rhizoidal outgrowths from each of the central cells of a trailing branch, the cortical cells being unmodified (*Pl. XXII, fig. 27*). The differences in the chromatophores are similar to those noted in the Rhodomelaceæ.

Ceramium differs in many respects from the other genera described. Both *Ceramium rubrum* (Huds.) C. Ag. and *C. strictum* Harv. were carefully studied and found to agree closely in so far as the early development of the plantlet and the formation of the rhizoid are concerned. Shortly after it is sown, the spore produces a cell-wall (*Pl. XXIII, fig. 24*) and a well-defined temporary holdfast. The latter is a granular disk of definite thickness, and mucilaginous in character, attached to the base of the spore (*Pl. XXIII, fig. 10*). The granules, embedded in a clear matrix, are often arranged in lines radiating from the axis to the rim of the disk (*Pl. XXIII, fig. 25*). The distances between the granules being least in vertical planes, the disk appears densest when viewed from the side. This peculiar body does not respond to the ordinary tests for cellulose, and is not dissolved after prolonged treatment with dilute potassium hydrate. It is affected neither by Hanstein's aniline blue nor safranin; but the granular portions stain deeply with hæmatoxylin and with Congo-red, and the whole with Bismarck-brown. The disk is, therefore, distinct from the cellulose wall of the spore and differs materially from ordinary vegetable mucilages, though it is probably closely allied to the latter. This temporary holdfast is not peculiar to plants existing in an unnatural environment, but has been found in very young plants growing on Chordaria. As the

spore develops, the first rhizoid pierces the disk, which then becomes disintegrated and finally disappears (*Pl. XXIII, fig. 26*).

After attaching itself in the manner described, the spore elongates and divides several times in parallel planes at right angles to its longer axis (*Pl. XXIII, figs. 11–13*). The basal cell, growing rapidly, produces a multicellular rhizoid at an early age; but large plantlets, which have already cut off corticating cells, occasionally show little or no tendency to form rhizoids (*Pl. XXIII, figs. 14, 15, 18*). The primary root-cell branches into several rhizoids, which are increased in number by outgrowths from the cell adjoining the first root-cell (*Pl. XXIII, figs. 17, 19, 20, 27*). Still later, the cortications near the base of the plantlet develop multicellular branching rhizoids of great length. All remain free throughout the life of the plant, and both primary and secondary rhizoids branch monopodially near the tip, and thus give rise to large multicellular disks of irregular outline (*Pl. XXIII, figs. 16, 22, 23, 28*). These indented clasping-disks are closely crowded together, cohering so as to form a large rounded holdfast, in which the various elements may be clearly distinguished. As both of the species are upright in habit, no secondary holdfasts are developed at any point of the mature frond. As in several other genera, the chromotaphores of the plantlets and of the holdfasts resemble those of the corticating cells rather that those of the central axis, the former being disks, the latter irregular branching bands (*Pl. XXIII, figs. 17* and *21*).

It is evident, therefore, that the species of the Ceramiaceæ examined differ greatly both in the manner of development and the form of the holdfast, agreeing only in the production of one primary root-cell. *Spermothamnion Turneri* forms at various points short unicellular rhizoids with terminal disks, branching does not occur, and cortications are not developed. *Griffithsia Bornetiana* produces a large spreading holdfast composed entirely of a pseudo-parenchymatous tissue arising from the primary root-cell. Callithamnion, Spyridia, and Ceramium have primary

root-cells, from which spring rhizoids terminating in multicellular disks. Others originate in the cell adjacent to the basal cell and in the cortications. In addition the first two possess a strengthening mass of intracuticular root-fibers, but Ceramium is quite destitute of them.

Thus, while of some value in showing relationships, it will be seen that the chief interest in a comparative study of the developing spores and holdfasts of the Florideæ would be in variations dependent upon differences in light, temperature, or the density of the surrounding medium, and in adaptations to vegetative reproduction.

In closing, I would acknowledge my indebtedness to Dr. Setchell, who, in 1895, suggested the holdfasts of the Rhodophyceæ as a subject that would repay investigation; to the late Dr. Humphrey, under whose helpful and suggestive direction the work described in this paper was practically begun; and to Professor Penhallow for kind advice.

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EXPLANATION OF PLATES XXI–XXIII.

PLATE XXI.

FIG. 1. *Rhabdonia tenera* J. Ag., carpospore 9 hrs. after sowing. × 334.

FIG. 2. *R. tenera*, 2 days old. × 334.

FIGS. 3–11. *R. tenera*, from 4 to 17 days old. × 334.

FIG. 12. *Lomentaria uncinata* Menegh., carpospore. × 334.

FIGS. 13–15. *L. uncinata*, 6 days old. × 334.

FIG. 16. *L. uncinata*, an unusually large specimen, 6 days old. × 213.

FIGS. 17–19. *Champia parvula* Harv., plantlet resulting from the germination of a carpospore, 8 days old. × 334.

FIG. 20. *C. parvula*, holdfast of a plantlet growing on Polysiphonia. × 213.

FIGS. 21, 22. *Lomentaria uncinata*, bases of mature plants.

FIG. 23. *Chondria tenuissima* (Good. et Wood) C. Ag., tetraspore shortly after it was sown. × 233.

FIGS. 24–28. *C. tenuissima*, plantlets developed from carpospores, from 2 to 4 days old. × 233.

FIG. 29. *C. tenuissima*, plantlet resulting from the germination of a tetraspore, 10 days old. × 233.

FIG. 30. *C. tenuissima* found growing on mature Chondria. × 233.

FIGS. 31, 32. *C. tenuissima*, 3 days old. × 233.

FIG. 33. *C. tenuissima*, 12 days old. × 213.

FIG. 34. *C. tenuissima*, 14 days old. × 213.

FIGS. 35, 36. *C. tenuissima*, 5 days old. × 213.

FIG. 37. *C. tenuissima*, portion of mature holdfast, stained with methyl blue. × 213.

FIGS. 38–40. *C. tenuissima*, holdfast of plants found growing on mature Chondria, stained with methyl blue. × 333.

FIGS. 41–56. *Polysiphonia violacea* (Roth) Greville.

FIGS. 41–45. Carpospore and plantlets from 1 to 5 days old. × 400.

FIG. 46. Plantlet 7 days old. × 633.

FIGS. 47, 48. Plantlets found growing on *Scytosiphon lomentarius* Ag. × 400.

FIG. 49. Plantlet, result of germinating carpospore. × 213.

FIGS. 50–56. Ends of primary rhizoids of plantlets 12 days old. × 400.

PLATE XXII.

FIGS. 1–10. *Polysiphonia violacea* (Roth) Grev.

FIG. 1. Plantlet growing on *Scytosiphoul omentarius* Ag. × 400.

FIG. 2. Plantlet 3 days old. × 400.

FIG. 3. Plantlet 9 days old. × 400.

FIGS. 4, 5. Plantlets 12 days old. × 233.

FIG. 6. Holdfast showing rhizoids springing from corticating cells. × 54.

FIG. 7. Plantlet 12 days old. × 213.

FIG. 8. Clasping disk of rhizoid of plant growing on *Zostera marina* L. × 400.

FIGS. 9, 10. Plantlets 9 and 11 days old. × 400.

FIGS. 11–29. *Spyridia filamentosa* (Wulf.) Harv.

FIG. 11. Carpospore. × 400.

FIGS. 12–18. Plantlets from 2 to 12 days old. × 400.

FIGS. 19–23. Bases of plantlets, showing primary cells and clasping disks. × 400.

FIG. 24. Base of rhizoidal branch (*c.* of *fig. 28*). × 213.

FIG. 25. Edge of mature holdfast, in optical section. × 157.

FIG. 26. Transverse section of frond, showing that the origin of rhizoidal branches is in the corticating cells; somewhat magnified.

FIG. 27. Procumbent branch, near *18a*, with rhizoidal outgrowths from central cell. × 333.

FIG. 28. Creeping branch, slightly magnified.

FIG. 29. Uncorticated secondary rhizoid with disk. × 333.

FIGS. 30–43. *Dasya elegans* (Martens) C. Ag.

FIGS. 30, 31. Germinating tetraspore. × 400.

FIG. 32. Segmenting carpospore 2 days old. × 400.

FIGS. 33–35. Segmenting tetraspore. × 400.

FIGS. 36–38. Plantlets 12 days old, resulting from the germination of tetraspores. × 400.

FIGS. 39–42. Plantlets 17 days old, resulting from the germination of carpospores; *figs. 39, 42* show only the root-cell and disk. × 400.

FIG. 43. Portion of mature holdfast, in optical section. × 233.

PLATE XXIII.

FIGS. 1–9. *Dasya elegans* (Martens) C. Ag. Plantlets resulting from the germination of carpospores; in some cases only the primary root-cell and disk are shown; from 12 to 20 days old. ×400.

FIGS. 10–23. *Ceramium rubrum* (Huds.) C. Ag.

FIG. 10. Germinating carpospore 2 days after sowing. × 633.

FIGS. 11–17. Plantlets from 3 to 8 days old; in *figs. 15, 16* only the basal cells and primary rhizoids are shown. × 400.

FIG. 18. Plantlet found growing on Polysiphonia. × 400.

FIGS. 19, 20. Plantlets 9 days old. × 400.

FIG. 21. Plantlet growing on Polysiphonia. × 400.

FIG. 22. Plantlet 5 days old, showing early branching of the primary rhizoid. × 400.

FIG. 23. Holdfast of a rather young plant. × 213.

FIGS. 24–28. *Ceramium strictum* (Harv).

FIG. 24. Carpospore 36 hours after it was sown. × 400.

FIG. 25. Plantlet 3 days old. × 233.

FIGS. 26, 27. Plantlets about 7 days old. × 400.

FIG. 28. Primary root-cell and disk of mature plant. × 400.

FIGS. 29–32. *Callithamnion Borreri* Ag., plantlets from 2 to 6 days old. × 213.

FIG. 33. *C. Borreri*, plantlet showing basal cell and rudimentary disk, 6 days old. × 213.

FIG. 34. *C. Borreri*, primary disk of plantlet 9 days old. × 333.

FIG. 35. *C. Baileyi* Harv., mature holdfast, in optical section. × 213.

FIGS. 36, 37. *C. Borreri*, base of plantlets 6 days old, each showing primary disk. × 400.

FIG. 38. *C. Borreri*, plantlet 6 days old. × 213.

FIG. 39. *C. Baileyi*, a portion of a mature holdfast. × 100.

FIG. 40. *Spermothamnion Turneri* Aresch., branch with clasping disk. × 213.

FIG. 41. *S. Turneri*, plantlet 6 days old; nine cells of the filament are not represented. × 213.

FIGS. 42, 43. *S. Turneri*, mature holdfast. × 213.

BRIEFER ARTICLES.

A PRACTICAL REFORM IN THE NOMENCLATURE OF CULTIVATED PLANTS.

SOME years ago the Society of American Florists adopted Nicholson's *Dictionary of Gardening* as its authority for the names of cultivated plants until *Index Kewensis* should be completed. *Index Kewensis* has been finished for several years, but no florist, nurseryman, or seedsman has standardized the names in his catalogue until in the case about to be described. Moreover, no tradesman, so far as I know, has ever tried to be absolutely consistent in his names or to follow any one botanical authority. Nevertheless, the seedsmen, nurserymen, and florists are bringing up the perplexing problems of nomenclature, making resolutions, formulating rules, appointing committees, and adopting standards. An intelligent minority is always pressing for reform. Standards are adopted and no one follows them. Will they ever be followed? Some say no, and affirm that there are essential elements in trade that will always make horticulture and botany conflict more or less. I have long thought otherwise, and now have to record an experiment that seems to show an entirely practical way of standardizing the nomenclature of trade catalogues.

It seemed to me very important that some particular catalogue should be compared with *Index Kewensis*, and every name altered to conform with it. Every name not found in *Index Kewensis* should then be compared with Nicholson's *Dictionary of Gardening* and harmonized with that, if possible. This process has actually been followed in the catalogue of F. H. Horsford, of Charlotte, Vt. The case has proved to be an interesting one, and its main features should be put on record, for some of our best horticultural firms, I believe, are willing to standardize their catalogues, if only they are shown just how to do it. We should bear in mind that the principles of nomenclature, so familiar to every botanist, are entirely unfamiliar to the busy horticulturist with a living to make.

At the outset one might readily imagine that any nurseryman, seedsman, or florist who has access to *Index Kewensis* and Nicholson

can do this kind of work himself for his own catalogue. This idea will have to be modified. Some tradesmen can do it themselves, but most cannot. However, all the important ones can hire it done, and cheaply. It is a job that would be exceedingly dry and uncongenial to many excellent business men. Competent students, however, can be found at the universities who are making their way, and would be glad of such work. A thousand names can be standardized for five dollars, at the rate of twenty cents an hour for twenty-five hours. This does not include the task of rearranging names in alphabetical order, or the reading of proof (as some cataloguers may prefer to do this themselves), but only the work of supplying the information necessary to the cataloguer.

There are about seven hundred species in the Horsford catalogue, and only twenty-five of those names are not to be found in *Index Kewensis* or Nicholson. This is less than 4 per cent., which is surprisingly low when one reflects on the great number of novelties since 1893; but Mr. Horsford sells largely of native plants, and these have received comparatively few trade names. Moreover, a goodly proportion of these twenty-five missing names are those of hardy native ferns. *Index Kewensis* has no ferns.

One barely begins to compare the names of a catalogue with *Index Kewensis* when he is confronted with an important problem of which this is a picture:

Alyssum saxatile Crantz = A. gemonense.
Alyssum saxatile Linnæus.

Now, how does the "standardizing clerk" know whether his employer has in his nursery the *Alyssum saxatile* of Crantz or of Linnæus? Probably he could give a shrewd guess. Possibly he may have both of the original descriptions at hand, and the plants also, but the chances are all against it. But, putting such considerations aside, this is a matter of identification, not of nomenclature, and the distinction between these two kinds of work must be grasped at the outset, or nothing can be done. The duty of the nomenclature clerk is clear. He assumes that the plant in the nursery is the one that *Index Kewensis* prints in ordinary type. The names in ordinary type, he knows, are considered by *Index Kewensis* to be the tenable ones, while all those in italics are synonyms. It is to Mr. Horsford's business interest to do all he can to find out whether the *Alyssum saxatile* in his nursery is properly named or is really *Alyssum gemonense*. Most tradesmen,

however, do not have the time, the training, or the books to determine all their plants. Identification is the work of the botanist, and the day will come, I hope, when all the plants in the nurseries may be identified by specialists. Such work, however, is many times more costly than merely following a uniform system of nomenclature. The distinction between identification and nomenclature cannot be urged too strongly.

Another case is also interesting and occurs frequently:

Aconitum autumnale Lindley = A. Fischeri.
Aconitum autumnale Reichenbach = A. Napellus.

In this case *Index Kewensis* does not give any *Aconitum autumnale* in ordinary type, and therefore it recognizes no good species of that name. Here, again, the duty of the nomenclature clerk is clear, and he writes:

Aconitum autumnale (Lindl. or Reich.?).

It is not for him to decide whether the plant in the nursery is really *A. Fischeri* or *A. Napellus*. He has called the attention of the nurseryman to the question, and leaves it open. The nurseryman, perhaps, cannot settle the question while his catalogue is going to press, and he follows the suggestion of the nomenclature clerk literally. Perhaps he may not be able to settle the point for several years, but trade reasons are constantly urging him to get the point settled. Meanwhile it is consistent and honest to indicate a doubt. Two entirely different things have been cultivated under the name of *Aconitum autumnale*, but no one will suspect it if the fact were concealed. Honest doubt inspires confidence.

The next point will have great weight with the horticulturists. Mr. Horsford catalogues *Anemone montana* and *Anemone sylvestris* as two different things, but *Index Kewensis* says that the first is a synonym of the second. The nomenclature clerk allows Mr. Horsford to sell his two distinct things under the same names as before, but one of the entries now reads:

Anemone montana (*A. sylvestris* according to *Index Kewensis*, but horticulturally distinct with me).

This is perfectly clear, but too long, and a shorter way will be shown presently. The important things to note are two. First, the nurseryman is as free as before to differ in opinion from the official authority, but now he is consistent throughout, and supplies the opinion of

the recognized authority as well as his own. Secondly, every name that appeared in the old catalogue appears in the new, but many of the old names now appear as synonyms or cross-references. No trade name that means money need be omitted. A shorter method of expressing a difference of opinion from official standards is to put an explanatory note at the beginning of the catalogue to this general effect: "Names in brackets show a difference of opinion." Thus we catalogue:

Anemone montana [*A. sylvestris*].

This means that *Index Kewensis* considers *A. sylvestris* to be the proper name of the species and *A. montana* the same thing, or perhaps only a botanical variety, while we consider that the two things are distinct for horticultural purposes. Instead of suppressing the opinions of others that conflict with our own, we tolerate them both, and place them side by side.

The commonest situation that needs change is shown by the following example: Mr. Horsford advertises for sale *Achillea Eupatorium*. *Index Kewensis* says this equals *A. filipendulina*. The best way for him to do is to advertise

Achillea filipendulina. (*A. Eupatorium.*)

This makes a great many changes in the alphabetical arrangement of species, and sometimes of genera.

The other way to do is to advertise under the old name, with the new name in parenthesis, and perhaps in different type, and an explanation in some prominent place of the device used consistently throughout the catalogue. This is a far less satisfactory method. The only thing that can be said for it is that it supplies the information. Doubtless it would be cheaper in some cases than revolutionizing a whole catalogue, but if a thing is worth doing at all it is worth doing well.

A few minor points may be briefly mentioned. The name of the author of a species would better not be given in trade catalogues unless absolutely necessary. It makes a catalogue look too dry and technical and unattractive. There is no officially accepted authority for popular names or for names of varieties, whether botanical or horticultural. *Index Kewensis* is not supposed to take account of anything below the species. Nicholson gives some varieties and also popular names.

It sometimes happens that *Index Kewensis* gives a species twice in

ordinary type as if both were tenable. For instance, there is a *Campanula strigosa* of Vahl and a *Campanula strigosa* of Solander, both in ordinary type. In such a case the nomenclature clerk may write:

Campanula strigosa (Solander or Vahl?).

It is well to explain in the beginning of a catalogue which names are the proper ones and which are the synonyms. The latter are commonly in italics. It makes little difference how a catalogue is arranged, provided that there is a full index somewhere. Few indexes are full enough. The Horsford catalogue has no index, and there are seven departments, the arrangement being alphabetical under each department. The fact that there are seven departments should therefore be prominently stated, and the seven departments listed in the space of an inch or two in such a way that the mind can take in the whole scheme. —WILHELM MILLER, *Cornell University*.

THE BOTANICAL GARDEN AND INSTITUTE IN PADUA.

THE readers of the BOTANICAL GAZETTE may be interested to hear something of the ancient Botanical Garden of the University of Padua, instituted by the Venetian Senate in a decree of the twenty-ninth of June, 1545, through the wise forethought of Francis Bonafede in 1543.

The director, Professor P. A. Saccardo, who has recently improved the Institute and the Garden, published some interesting notices upon the 350th anniversary of its foundation from which I take the greatest part of this note.[1]

Professor Saccardo's activity turned, in the first place, to increase the library, initiated in 1770 by one of his predecessors, John Marsili, and enriched afterwards by Professor Bonato and Professor De Visiani, so that it contains already more than 10,000 volumes. Among the books, besides about forty periodical reviews and many valuable works, I must mention the oldest botanical book with instructive figures, viz., *Herbarium Apuleji Platonici*, printed in Rome in 1479.

The director has filled up during recent years the series of works on the floras, especially on the foreign ones, to make easier the labor

[1] SACCARDO, P. A.: L'Orto botanico di Padova nei 1895 (anno CCCL dalla sua fondazione). Padua. 1895. Quarto, with one topographical and eight heliotype plates.

of setting in order the herbaria, which he was then disposed to begin and which is now well advanced.

A hall, built in 1842 as a greenhouse, was arranged in 1892 to contain the general herbarium, consisting of 396 packets disposed horizontally in appropriate compartments of two great cases, with about 24,000 species represented by 60,000 specimens; the Dalmatian herbarium, composed of 37 packets with 2500 species and 10,000 specimens; and the cryptogamic herbarium, composed of commercial collections and those presented to the University.

The phanerogamic herbarium, especially from the Venetian provinces (65 packets, 3500 species, 10,000 specimens) is Saccardo's own and is placed in a great hall which was adapted in 1880 as a laboratory and contains also collections and materials necessary for scientific instruction. The students do their laboratory work there, under the attendant's guidance.

The mycologic herbarium, which is also the property of the director, deserves particular mention. It is in the director's room, in 66 cases ($50 \times 36 \times 23$ cm), and represents more than 30,000 specimens, many of which come from mycologists, some very rare. Saccardo's herbarium and mycologic library (300 volumes and 2300 pamphlets) are the important scientific material with which that clever mycologist wrote the classic *Sylloge Fungorum*. In the director's room near the library are the archives of the garden where there are the interesting autographs of Malpighi, Prospero Alpino, Cesalpino, and Pontedera.

Professor Saccardo has also increased the collection of portraits of botanists, a collection initiated by his predecessor, Professor Robert De Visiani. It is really well furnished, especially through gifts made by Baron Todaro, of Palermo, the son of the late botanist Augustin Todaro. It contains about 600 portraits, among which there are several of American botanists and of botanists who have studied the American flora.

In the lecture hall, built in 1842, which can contain two hundred men, there are portraits of seventeen professors of botany, in oil or black-and-white. Three weekly lessons on general botany are given in this hall by the titular professor; two free professors give free lessons (two a week) especially to naturalists and chemists; Dr. Adrian Fiori, attendant to the chair, delivers a course on cryptogams and plant pathology; and the writer delivers a course on plant physiology, with applications to agriculture.

So much for the Institute; but a great deal might be added as to the Garden and its greenhouses, which are rich in interesting plants.[2] Classic plants are a *Chamærops humilis* L. var. *arborescens*, 9.5^{m} high, planted about 1585, and visited September 27, 1796, by Goethe, wherefore it is known as "Goethe's palm tree;" a *Tecoma grandiflora* Del., admired by Goethe for its beautiful flowering; a very old *Vitex Agnus-castus* L. (about 345 years old); an *Araucaria excelsa* R. Br. 20^{m} high, kept in a special greenhouse; many very beautiful trees (*Gymnocladus Canadensis* Lam., *Gingko biloba* L., *Diospyrus Lotus* L., *Carya oliviæformis* Nutt., etc.). The greenhouses also are furnished with beautiful plants, among them an *Astrocaryon Chonta* Mart., a *Cycas circinalis* L., a *Cycas revoluta* Thunb., a *Pandanus utilis* Bory, a *Livistona australis* R. Br., many Cactaceæ and Orchideæ.

More than 5700 plants are cultivated in pots, to which we must add 110 old trees in the open air, 412 younger trees and shrubs, and 26 old greenhouse trees. — J. B. DeToni, *Padua, Italy.*

CONTRIBUTIONS FROM MY HERBARIUM.

Crataegus Sauratonae, n. sp. — A small tree 3–4^{m} in height, with an oval crown and ascending or spreading branches, the branches generally very crooked, as well as the slender twigs; twigs ash-gray in color, and armed, though sparingly, with stout gray or reddish spines, the twig of the season glabrous and red-brown: leaves glabrous, 2–5^{cm} long, obovate or elliptic, or rhombic-ovate, acute and sharply serrate above the middle, mostly entire towards the narrow base, with three or four pairs of prominent veins; the slender petiole 0.5–1^{cm} long; stipules, bud scales, and floral bracts not conspicuously enlarging, and early deciduous: flowers in rather small glabrous corymbs; sepals entire, lanceolate, glabrous; pedicels 1.5–3^{cm} long, glabrous, the red fruit about 12^{mm} in diameter, or more; styles four or five.

Related to *Crataegus collina* Chapm., and separated from it by having smaller glabrous foliage, sharply serrate leaves, and larger fruit. This species has been collected in wet flats along streams in the Sauraton mountains of North Carolina; on the tributaries of the Neuse river, in Granville county, N. C.; and along streams in Caswell county, N. C.; growing with *Crataegus viridis* L., the white oak, and shag-bark hickory.

[2] For the accounts of these see R. de Visiani: Di alcune piante storiche del giardino di Padova. Padua, 1856. — G. B. DeToni: Alberi e frutici ragguardevoli nei giardini di Padova. Padua, 1887.

CRATAEGUS COLLINA Chapman, which has been reported by Mr. C. D. Beadle from the mountains of North Carolina, is not uncommon in that state as far eastward as Durham county, generally growing along the edges of fields or in coppice woods.

CRATAEGUS VAILIAE Britton seems to be quite distinct from the closely related *C. uniflora* Moench., often having long, erect, virgate branches, and becoming a tall shrub; while *C. uniflora* is generally lower, seldom more than 1[m] in height, with spreading or horizontal branches. It is found in North Carolina as far eastward as Durham and Raleigh.

Crataegus Chapmani (Beadle), n. comb. *Crataegus tomentosa Chapmani* Beadle, BOT. GAZ. **25**:36. 1898. This tree is clearly worthy of specific rank. The much broader leaves and more prominent veins, smaller fruit in larger corymbs, and more slender spines separate it at once from all forms of *C. tomentosa*. In leaf characters and especially in the numerous pairs of prominent veins there is much resemblance to *C. punctata* Jacq. I find *Crataegus Chapmani* to be not uncommon in Ashe county, N. C., and Grayson county, southwestern Virginia.

FRAXINUS PROFUNDA Bush.—This tree has hitherto been reported only from the lower part of the Mississippi valley and the Gulf region. I have observed it, however, in a few places along the Atlantic coast as far north as Great Pungo swamp, Washington county, N. C. So far as noticed on the Atlantic coast the tree is confined to the largest river swamps, and the deeper flat swamps with stiff soils, growing with oaks, hickory, and occasionally loblolly pine.

QUERCUS TEXANA Buckl.—I reported this tree as occurring east of the Alleghany mountains, in this journal two years ago (**24**: 376. 1897) in the Piedmont region of the Carolinas and Virginia. I have subsequently detected it on the Atlantic coastal plain, in Onslow county, N. C., within twenty miles of the Atlantic coast, where I saw a magnificent group of trees, some of the specimens being 35[m] high, and more than 1[m] in diameter.

HICORIA CAROLINAE-SEPTENTRIONALIS Ashe.—This tree proves to be not uncommon in certain portions of the Piedmont regions of the south Atlantic states. It prefers dry, rocky soils, steep declivities, and the crests of sandy ridges, though it occasionally enters lowlands. Along a narrow range of low slaty and rocky hills which extends with interruptions from Maryland to middle South Carolina the tree is fre-

quent; while in central and northwestern Georgia it is more common, and it occurs, though locally, in middle Tennessee.

FOTHERGILLA MONTICOLA Ashe.—The recent discovery of this local shrub at Chapel Hill, N. C., makes another station for it about 150 miles east of any previously reported locality. It grows there on a rocky hillside with *Rhododendron Catawbiense* Mx., and the chestnut oak. This is also the most eastward station for *Rhododendron Catawbiense* Mx. Dr. J. K. Small reported Crowder's mountain as being the most eastward station, but Chapel Hill is 140 miles further east, and has an elevation 1000 feet less than that of Crowder's mountain, being only 500 feet above sea level. The *Systematic Flora* (2: 42) gives the plant as occurring only at high elevations. This rhododendron is also found abundantly along the Oconneechee hills, twelve miles northwest of Chapel Hill, and at a slightly higher elevation. With it at this place is *Aconitum reclinatum* Gray, one of the most local species of the genus, and hitherto supposed to be confined to higher elevations, 5000–6500 feet, in the southern Alleghanies.—W. W. ASHE, *Biltmore, N. C.*

TWO NEW MICHIGAN FUNGI.

Tubaria luteoalba, n. sp.—Pileus 1–2.5^{cm} broad, thin, convex, becoming plane, finally centrally depressed, the margin sometimes becoming partly or wholly upturned, hygrophanous, white, creamy or yellowish, silky-squamulose near the margin from the remains of the veil, margin striate when moist: stem 1.5–2^{cm} long, 0.3–0.5^{cm} thick, hollow, slightly enlarged at base, whitish, silky, downy at base, often curved: lamellæ adnato-decurrent, 0.2–0.4^{cm} broad, subdistant, at first nearly white but soon ochraceous from the spores: spores elliptical, 4–5 × 6–8 μ.—On decaying stems and leaves of weeds and grass, on low wet ground near Michigan Agricultural College, April 1897.

This fungus resembles *T. furfuracea* in form and habit, but is smaller, lighter in color, and in every way more delicate than that species. The spores are also smaller and lighter in color. From *T. autochthona* it differs in its larger size, form of stem, and habitat. The veil sometime forms a fibrous zone on the stem. It has not been collected in any other locality.

Galera crispa, n. sp.—Pileus 1.5–3.5^{cm} broad, membranaceous, persistently conico-campanulate, subacute, uneven and somewhat rivulose,

ochraceous-brown on disk, lighter toward the margin which becomes crenulate and upturned in older specimens, slightly pruinose at first, rugulose and a little paler when dry: lamellæ slightly adnexed, not crowded, rather narrow, interspaced with anastomosing veins, much crisped, at first nearly white, then becoming ferruginous from the spores: stem 7–10^{cm} long, 0.1–0.3^{cm} thick, tapering from the somewhat bulbous base, yellowish-white, pruinose at base, hollow, fragile: spores 8–10μ broad, 12–16μ long.— In grass in dooryards and pastures, June and July.

The specific name is based on the peculiar character of the gills which are always crisped as soon as the pileus is expanded. Professor Charles H. Peck, to whom specimens of the above fungi were referred, and who very kindly reported on them, suggested that this might be a variety of *G. lateritia*, unless the peculiar character of the lamellæ proved to be constant. The fact that specimens possessing this character have been collected in the same localities during the past three seasons seems sufficient proof of the constancy of this character, and consequently, would indicate that this form is worthy of specific rank. —B. O. Longyear, *Michigan Agricultural College.*

MEXICAN FUNGI. II.[1]

The following species of Ustilagineæ were collected by me in 1896 and 1898, and all, except the three marked with an asterisk, have been examined by P. Hennings, of Berlin.

Ustilago Rabenhorstiana P. Henn. On *Panicum filiforme.* G...dalajara, Oct. 12, 1896.

Ustilago pamparum Speg. On *Setaria.* City of Mexico, Oct. 2, 1896.

Ustilago Ulei P. Henn. On *Chloris submutica.* City of Mexico, Oct. 2, 1896.

Ustilago Dieteliana P. Henn. On *Tripsacum dactyloides.* City of Mexico, Oct 1, 1896.

Ustilago Hilariæ P. Henn. On *Hilaria cenchroides.* City of Mexico, Oct. 2, 1896.

Ustilago Ægopoginis P. Henn. On *Ægopogon cenchroides* P. Henn. City of Mexico, Oct. 3, 1896.

[1] For previous paper see Bot. Gaz. **24**: 23. 1897.

USTILAGO BRUNKII Ell. and Gallw. In culms of *Andropogon perforatus*. Cardenas, Mexico, Oct. 22, 1898.

USTILAGO NUDA (Jens.) Kell. & Swingle. On *Hordeum vulgare*. Toluca, Sept. 19, 1898.

USTILAGO CENCHRI Lagerh. On *Cenchrus* (*tribuloides?*). Cardenas, Oct. 22, 1898.

Ustilago Holwayana P. Henn., n. sp. Soris in spicis, eas destruentibus, longe cylindraceis, primo membrana pallide cinerea velatis, atris; sporis subglobosis vel ellipsoideis, subacutangulis, atro-violaceis, 13–16×12–15 μ; episporo verrucoso, atro.—In spicis *Paspali velutini*. Patzcuaro, Michoacan, Oct. 19, 1898.

Ustilago Andropoginis-hirtefolii P. Henn., n. sp. Soris in paniculis, ovaria destruentibus, longe cylindraceis, membrana cinnamonea vestitis, dein pulverulentis, atro-olivaceis vel fusco-olivaceis, 9–14 μ; episporo granuloso verrucoso.— In paniculis *Andropogonis hirtifolii pubifloræ*. Patzcuaro, Michoacan, Oct. 20, 1898. Apparently quite distinct from all the species known on Andropogon.

Ustilago Panici-proliferi P. Henn., n. sp. Soris in paniculis, eo omnino destruentibus, membrano cinerea tectis, dein pulverulentis atro-olivaceis; sporis subglobosis, acutangulis, pallide olivaceo-fuscis, intus granulatis, 7–9 μ; episporo levi.—In paniculis *Panici proliferi acuminati*. City of Mexico, Oct. 10, 1898. This species differs from *U. Panici-miliacei* (Pers.) Wint. in its much smaller spores, and in having the sori covered with an ashy-gray membrane; and from *U. vesiculosa* P. Henn. and *U. pustulata* Tr. & Earle in its smooth lighter colored spores. The sori and general appearance are also different.

*USTILAGO PARLATOREI F. de Wald. On *Rumex Mexicanus* Meissn. Toluca, Mexico, Sept. 19, 1898.

*USTILAGO TRITICI (Pers.) Jens. On *Triticum vulgare*. City of Mexico, Oct. 11, 1898.

*USTILAGO ZEÆ (Beckm.) Ung. On *Zea Mays*. City of Mexico, Oct 10, 1898.

CINTRACTIA AXICOLA Cornu. On *Fimbristylis*. Cuernavaca, Mexico, Sept. 26, 1898.

CINTRACTIA LEUCODERMA (Berk.) P. Henn. On *Rhynchospora*. Jalapa, Mexico, Oct. 3, 1898.—E. W. D. HOLWAY, *Decorah, Iowa*.

OPEN LETTERS.

TO BRYOLOGISTS.

THE undersigned desires to make a full canvass of all working bryologists and collectors of mosses, both American and foreign, believing that a better general acquaintance will further both the friendly and scientific spirit. To this end the following data are cordially solicited from all who have not already sent them:

1. Name in full; age; vocation.

2. Average time your vocation annually permits you to devote to mosses.

3. A list of your bryological publications; also a list of exsiccati you may have distributed.

4. Have you worked on any foreign moss flora? State in which geographical region you are most interested.

5. Which genera, or larger groups, are you making your specialty?

6. Are you desirous to have referred to you for critical examination species that fall in the line of your special interest?

7. Do you exchange mosses? If so, what material do you offer?

A circular embodying these questions was sent out in June of the present year. It was answered so approvingly and enthusiastically that I feel justified in making an additional effort to make the data as complete as possible, to put them when collected into permanent form, and to place them finally in the hands of each one interested.—JOHN M. HOLZINGER, *Winona, Minn.*

CURRENT LITERATURE.

BOOK REVIEWS.

Botanical teaching.

A TOPIC which is or should be of deep interest to professional botanists in our higher institutions is the nature and quality of the botanical instruction in the secondary schools. Many of them have shown their interest by personal endeavor to help teachers to improve the scope of their courses and to secure proper equipment of laboratories for instruction. This endeavor is bearing fruit, and the rapid improvement in botanical teaching augurs well for future development. Besides the innumerable fugitive addresses to teachers' associations and institutes, several modern text-books and laboratory guides are helping along the good work.

Professor Ganong now contributes a book which will do much to assist teachers to strengthen their botanical work. This book, *The Teaching Botanist*, has a pedagogical purpose, as distinct from the texts and laboratory handbooks. It consists of two independent parts. The first is made up of eight essays on botanical pedagogics, full of excellent ideas, useful suggestions, and earnest admonitions. Many of these reforms botanists have long been advocating. Now that the ideas are pithily put and in permanent form, they will become more widely efficient than heretofore. Those who have proclaimed the new gospel will be delighted to have this book to which they may refer teachers seeking such help. It will save reams of letters and hours of talk.

If we may choose among the good things in this part, the essays on "What botany is of most worth," "On things essential to good botanical teaching," and "On some common errors prejudicial to good botanical teaching" are probably the most useful. But the suggestions on drawing and description, on laboratories and their equipment, on collections, and on books, are excellent and sure to be helpful.

The second part consists of "an outline for a synthetic elementary course in the science of botany," conforming to the principles elucidated in the first part. This course consists of two divisions, the first to elucidate general principles, and the second to present the chief features of the larger groups of plants. The course is divided into various topics with a series of questions and directions which might be put directly into the hands of pupils. These are followed by notes regarding the materials required and remarks on the pedagogical import of the various points called for.

Doubtless few teachers will want to follow exactly this course, nor does the author expect them to do so; but many will certainly derive great help by selecting from it the topics appropriate to their own conditions and having clearly before them the didactic value of the laboratory work.

It may be worth while to point out that the author's principles, which one cannot escape, do not compel the conclusion that it is best to begin the elementary course with a study of seeds. The teacher who now begins by introducing the student to the simple algæ need not feel that he must abandon this method. The excellent principles presented in the second essay may be as well developed by another method. And it is only fair to say that Professor Ganong advises each teacher to make out his own course.

University men will do well to read Dr. Ganong's essays and recommend the book to every teacher of botany.—C. R. B.

Buds and stipules.

SIR JOHN LUBBOCK has published a book with the above title in the well-known International Scientific Series.[1] There is little or no attempt to give anything new, but rather to place before the world in a somewhat popular style the most interesting results of his previous study.[2]

The author was led to study stipules by the observation of Vaucher that some rock-roses have stipules and others not; the question arose: why? The study of stipules led on to a study of buds, especially their protective structures.

The order of the chapters does not seem particularly logical, and there appears to be more repetition than is needed, even in a popular work. The first two chapters deal in a general way with buds and stipules; the third with the development of leaves and stipules, *i. e.*, their organogeny. The fourth chapter takes up the protection of buds, which may be by older leaves, leaf bases or petioles, stipules, hairs, resins. Detailed examples are given under each head. The author thinks that the shape of leaves is often determined by the shape of the bud or seed, and he attempts to explain in this way why some leaves are lobed and others not. For example, oak buds are short, the leaves are folded in the bud, and hence are lobed. There is possibly a confusion here between *post hoc* and *propter hoc*.

There is a long chapter on the structure of buds, many species being mentioned. Chapter six treats of the forms of stipules, and it is shown how great a variety there is. In the seventh chapter the author discusses the subsidiary uses of stipules. Their general use he conceives to be to cover and protect the buds. They are often important also as organs of photosynthesis;

[1] LUBBOCK, JOHN: On buds and stipules. Crown 8vo. pp. xix + 239. *pl. 4, figs. 340.* London: Kegan Paul, Trench, Trübner & Co. L't'd. 1899. 5s.

[2] On stipules. Parts I–IV. Jour. Linn. Soc. Bot. **28, 30, 33.** 1890, 1894, 1897.

they may become tendrils, or spines, or glandular organs; or they may be rudiments, looking back to organs of use in another form.

There is a chapter also on the nature of stipules. There are three views as to what stipules are: (1) they are appendages of the leaves (Van Tieghem, Baillon, Gray); (2) they are autonomous organs, analogous to leaves (Lindley); (3) they are an integral part of the leaf. Lubbock holds the third view. The first view he regards as untenable because stipules originate independently of leaves and often before them; the second because the stipule bundles are derived from the foliar bundles.

The book is full of illustrations and very suggestive, though it seems that there is too great a certainty as to just what everything is for.—HENRY C. COWLES.

An ecological text-book.

AMONG THE recent text-books for secondary schools none is so dominated by the new ecological standpoint as the book just issued by Dr. John M. Coulter. This is one of the series of "Twentieth Century Text-books," in course of publication by Messrs. D. Appleton & Co.[3]

It is the first of a pair of books, each representing work for half a year, but independent. The second, with the title *Plant Structures*, is to be issued shortly. It is to be dominated by morphology as the first is dominated by ecology. In the judgment of Dr. Coulter the order in which he issues the books is the proper one for presentation in an elementary course. This sequence is likely to meet with the criticism that the student, in ignorance of plant structure and without wide acquaintance with plant groups, is unable to appreciate ecological phenomena and principles. The author believes the advantages which counterbalance the disadvantages are (1) the obtaining of a true conception of plants in nature, (2) acquaintance with the large problems of plant physiognomy, and (3) the avoidance of the use of the compound microscope at the outset.

Though the physiognomy of vegetation is an interesting and perhaps most important phase of botany, it is doubtful whether at the present time the subject is well enough organized to justify its dominating an elementary course. It is still more doubtful whether it will be possible for many years to find teachers capable of presenting it. Granting the ecological aspect to be the ideal botanical course, the question is whether we are yet far enough away from the floristic or pseudo-taxonomic teaching to justify an attempt to reach so remote an ideal. The writer has already committed himself to the view that the simpler morphology and physiological topics should be first presented in an elementary course and therefore only states the pedagogical

[3] COULTER, J. M: Plant Relations, a first book of botany. 12mo. pp. x + 264. *figs. 206*. New York: D. Appleton & Company, 1899.

problem. To its solution Dr. W. F. Ganong contributes interesting arguments in a book elsewhere reviewed.

Readers of *Plant Relations* will be impressed by the terse and lucid style. Though the utmost condensation has been necessary, the author has preserved a simplicity of language and has attained a degree of accuracy which leaves nothing to be desired. The book is also striking in the number and beauty of its many illustrations, of which a large part are original. Among the finest ones are those derived from Schimper's recent treatise, *Pflanzengeographie*.

A very useful pamphlet of twenty pages, embodying suggestions to teachers for the use of the book, is designed to accompany it. It contains helpful remarks regarding the laboratory and field work which the author intends, of course, shall be prosecuted as the foundation for the study of the text.

We are sure that live school-teachers will welcome this book because it presents a new view of the plant world, valuable for instructional purposes and hitherto too much overlooked. University teachers will receive it gladly because it emphasizes one of the vital aspects of botany, and makes more effective the crusade against the cut and dried formalism of "analysis." — C. R. B.

Cytological technique.

INVESTIGATIONS upon the structure of protoplasm demand not only extreme skill in mechanical manipulation but also a knowledge of the principles underlying fixing, staining, and other details of microtechnique. A recent book by Dr. Alfred Fischer puts the whole subject of microtechnique upon a firmer and more philosophical basis and gives an up-to-date discussion of modern theories of protoplasmic structure.[4]

Part I, on fixing agents, considers in detail the solutions in common use and describes their action upon the various cell contents, as peptone, proalbumose, nucleic acid, nuclein, etc., etc. The numerous experiments with substances of known chemical composition should be of value in determining what are to be regarded as artifacts and what as structural elements of the tissue. The closing chapter on the fixation of cell contents will be found especially helpful by those engaged in cytological work.

Part II (128 pages) is devoted to staining. Both theory and practice are considered in detail. Some of the topics are as follows: The washing out of the fixing agent, and its significance in theories of staining; staining in simple staining solutions without differentiation; double staining with simple solutions; simultaneous double staining with mixed stains; impreg-

[4] FISCHER, ALFRED.: Fixirung, Färbung und Bau des Protoplasmas. Kritische Untersuchungen über Technik und Theorie in der neueren Zellforschung. 8vo. pp x + 362. *pl. 1. figs. 21.* Leipzig: Gustav Fischer. 1899. *M* 11.

nation; objections to the physical theory of staining; chromatin and the fundamental doctrines of staining. Here again experiments upon substances of known chemical composition occupy a large part of the space.

Part III deals with the structure of protoplasm. Spindles, centrosomes, and radiations are thoroughly discussed and artificial figures are compared with those occurring normally. Chromatin is treated in the paragraphs on granules. The various theories of the structure of protoplasm, as the granula theory, the network theory, the filar theory, and the foam-structure theory, are critically reviewed.—CHAS. J. CHAMBERLAIN.

Knuth's Handbook.

STUDENTS of the interrelations between plants and their pollinators, constituting a branch of what the Germans call "biology," and what Americans are coming to call "ecology," have learned their first lessons in large part from Christian Konrad Sprengel, once rector of the Lutheran Stadtschule at Spandau, Charles Darwin, and Hermann Müller, late Professor in the Realschule at Lippstadt. Some years since, Sprengel's book, "Das entdeckte Geheimnis der Natur im Bau und in der Befruchtung der Blumen," was reissued by Professor Paul Knuth, of the Ober-Realschule at Kiel; and an English translation of Müller's "Befruchtung der Blumen" has brought his work within reach of many persons not familiar with the German language. It appears that the original edition is no longer procurable, and Professor Knuth set himself the task of revising and reissuing it. The progress of this branch of science has been so great in the last quarter century, however, that he has found it better to write an independent work,[5] based on Müller's writings, but brought up to date.

For reasons not perfectly clear to the uninitiated, this has been divided into three parts: an introduction and bibliography, pollination observations in Europe and the arctic region, and extra-European studies in the ecology of flowers. The first two volumes are now issued, in three parts, ending with a comprehensive index. The third volume is announced as in course of preparation, and will be received with no little satisfaction on its completion. Few lines of botanical work are so fascinating or so accessible to the beginner as pollination studies, and with this book before him he should be able readily to sift the known from the new in his observations, so that the latter may be added to the former in suitable published form. It is doubtless too much to hope for an English translation, but the absence of one is only one more indication of the urgent need of a working knowledge of German on the part of every student ambitious to distinguish himself in modern scientific work. —WILLIAM TRELEASE.

[5] KNUTH, PAUL: Handbuch der Blutenbiologie unter Zugrundelegung von Hermann Müller's Werk, "Die Befruchtung der Blumen durch Insekten." Engelmann: Leipzig. 1898–9.

MINOR NOTICES.

A MONOGRAPH of the hypogaeous fungi of California has been published by Mr. H. W. Harkness.[6] One hundred and eight species are described, of which fifty-eight are new, with five new genera. There is unfortunately no artificial key or synopsis, so that the work will be of little value except to the specialist, and we fear he will have occasion to complain of the brevity of the diagnoses of new genera and species. These rarely exceed two or three lines, with few or no explanatory remarks.—C. R. B.

F. V. COVILLE and G. N. ROSE have published a list of plants collected by Mr. and Mrs. Leonhard Stejneger on the Commander islands during 1895 and 1897. These islands bear no trees, due, the authors think, to the violent wet winds that sweep over them during the winter. The geographic relationship of the flora is primarily Kamchatkan, with strong Aleutian and arctic elements, and there is almost no insular specialization. The list is reprinted from *The fur seals and fur-seal islands of the North Pacific Ocean*, part 4, pp. 352–361. 1899.—J. M. C.

"BOTANIZING" is the title of the new book by the author of *The Botanical Collector's Handbook*, Professor W. W. Bailey, of Brown University.[7] It embraces the material of the former volume but is completely rewritten and greatly improved. The amateur will here find the completest and best directions for all kinds of botanical collecting. The author has been assisted by various specialists, some making only general suggestions, others preparing the sections relating to particular families of phanerogams and the larger groups of cryptogams. Fifteen illustrations show useful apparatus for preservation of specimens. An index should have been added. The author (*in litt.*) asks readers to delete the words "the steppes of Asia or" on page 4, line 7.—C. R. B.

NOTES FOR STUDENTS

IN A PRELIMINARY PAPER read before the Botanical Society of America, at Columbus, Dr. Charles E. Bessey discussed the probable significance of apetaly and its connection with diclinism and dioeciousness. He suggested that well-established plants, as shrubs and trees, as well as those which mass their flowers may dispense with petals. Petaly is apparently correlated with entomophily, and apetaly with anemophily. Apetaly and diclinism appear to result from progressively increasing aphanisis. Lists of apetalous and dioecious plants were given and discussed.

[6] Proc. Calif. Acad. Sci. III. Bot. 1:241–286, *dbl. col. pl. 42–45*. 1899.

[7] BAILEY, W. W.: Botanizing: a guide to field-collecting and herbarium work. 12mo. pp. xiv + 142. *figs. 15*. Providence: Preston & Rounds. 1899.

AT THE COLUMBUS MEETING of the A. A. A. S., H. L. Bolley presented to Section G a paper by Lawrence Waldron on "The occurrence of calcium oxalate and lignin during the differentiation of the buds of *Prunus Americana*." It was found that the crystals of calcium oxalate occur in quite surprising abundance in the meristematic tissues of the bud, and in the very youngest stages of the scales of the bud; and that the oxalate becomes lessened in proportionate quantity as the tissues develop. Lignification of the hairs and scales of the bud commences at a very early period of their development. While it is usually assumed that calcium oxalate is a waste product of metabolism, its occurrence in such large quantities in the meristematic cells of the bud and scales would seem to indicate a question as to whether it has not a definite value at this point at this particular time in the life history of the plant.

PROTHALLIA OF LYCOPODIUM are so rare that the present paper, although based upon only half a dozen specimens, is a valuable contribution.[8] These prothallia resemble those of *Botrychium Virginianum* as described by Jeffreys. A vertical section shows a limiting layer of colorless cells, above which are several cells invested by an endophytic fungus. The cells of the upper half of the prothallium are entirely free from the fungus. The antheridium is developed from a single superficial cell and at maturity does not project above the surface. The archegonium, also developed from a single superficial cell, projects considerably. There are six or eight canal cells, the lowest presumably a ventral canal cell.

The value of the prothallium as a taxonomic character is discussed at some length, and the writer concludes that species of Lycopodium which possess similar prothallia cannot, on that ground alone, be regarded as closely related. The prothallium of *Botrychium Virginianum* in form, texture, endophytic fungus, position of sexual organs and subterranean saprophytic habit resembles the prothallia of *Lycopodium*, but the resemblance merely shows how an appearance of genetic relationship may result from modifications due to a similar subterranean saprophytic habit.—CHAS. J. CHAMBERLAIN.

AN EXCEEDINGLY interesting account of the fertilization of *Batrachospermum Bohneri* by W. Schmidle[9] has recently appeared. This author has worked on material gathered in Germany and his conclusions, while agreeing with my own studies in respect to the presence and behavior of the chromato-

[8] LANG, W. H.: The prothallus of *Lycopodium clavatum* L. Ann. Bot. **13**: 279–317. 1899.

[9] W. SCHMIDLE: Einiges über die Befruchtung, Keimung, und Haarinsertion von Batrachospermum. Bot. Zeit. **57**[1]: 125. 1899.

phores in the trichogyne and antherozoids, are very different as regards the activities of the nuclei and processes of fertilization.

The antherozoids of *B. Bohneri* differ from any that I have ever seen in having almost invariably two nuclei. When the antherozoid fuses with the trichogyne the nucleus nearest to the point of application passes into that structure and is usually followed by the second, which however may remain behind in the antherozoid.

The trichogyne and carpogonium of *B. Bohneri* have only one nucleus which lies in the carpogonium. One of the nuclei from an antherozoid passes the length of the trichogyne into the carpogonium through the constriction between the two structures. Fertilization takes places in the carpogonium, where the male nucleus fuses with the female.

The passage of the male nucleus causes the protoplasm in the trichogyne to gather into a peculiar dense mass which indicates a certain stage in the process of fertilization.

After fertilization the carpogonium becomes cut off from the trichogyne, and the latter may then contain one or more nuclei introduced from one or several antherozoids that fuse with it. Extensive fragmentation of these nuclei may occur later.

The phenomena described are in all respects compatible with our knowledge of the processes of fertilization. They accord fully with the accounts of Oltmanns and Wille for other members of the Rhodophyceæ.

I have realized for a long time that my account of Batrachospermum[10] left the problems considered in a very unsatisfactory state. The conditions that I described were exceptional and at variance with those so generally present in related groups of plants. However, at the time, I was convinced of the correctness of my position, and since that publication I have several times re-examined my material, always finding the same structures that I figured and described.

My chain of evidence is nevertheless incomplete in that I have not seen the mitotic figure which should give rise to the nucleus that I have supposed to be normally present in the trichogyne. Such a stage would be exceedingly difficult to find and recognize, and I have searched persistently for it. It is very important and even necessary for my views that its existence should be established. I have not been able to do this as yet, and in this respect acknowledge a weakness in my former position.

I do not wish to criticise the work of Schmidle further than to suggest the necessity of the most thorough studies in cytology in investigations of this sort. I wish we might have the details of nuclear fusion in fertilization and nuclear division in the antherozoid, together with an absolutely complete series of stages illustrating the process of fertilization.

[10] DAVIS: The fertilization of Batrachospermum. Ann. of Bot. **10**: 49. 1896.

These can only be obtained from material very carefully killed and fixed, perhaps after special methods. I must believe that we shall not feel sure of the processes in Batrachospermum until the technique of the investigation is developed to a point much superior to that of either Schmidle or myself.—BRADLEY MOORE DAVIS.

BARTHOLD HANSTEEN publishes the extended results of his researches on the synthesis of proteids in green phanerogams in Pringsheim's *Jahrbücher*.[11] He used *Lemna minor*, *Vicia Faba*, and *Ricinus communis* as experimental plants. His summary we translate:

1. In general, at least, light plays no direct rôle in the synthesis of proteids in the bodies of green phanerogamous plants. In these the formation of proteids occurs in active cells without the influence of light and independent of the time of year, if only suitable conditions for growth be present.

a. Glutamin, asparagin, urea, ammonium chlorid or ammonium sulfate combine with available grape sugar or—at least the four last named nitrogen compounds—with the direct reducing sugar formed in the digestion of starch.

b. Urea or glycocoll generally unite either with available cane sugar or probably indirectly reducing sugar.

2. The chemical nature of the immediately available carbohydrate is not unimportant for proteid synthesis; on it primarily depends whether the formation of proteid is effected or not.

3. The various amides (amido-acids) or nitrogen compounds are generally not physiologically equivalent for proteid formation. The best suited for this purpose is urea, whose transformation into proteid occurs as energetically with cane sugar as with grape sugar. On the contrary, leucin, alanin, and creatin cannot be looked upon as materials so suitable for proteid making; for even under the most favorable conditions, and equally whether direct or indirect reducing sugar in suitable amounts is simultaneously accumulated in the cells, proteid formation from these compounds fails.—C. R. B.

[11] Jahrb. f. wiss. Bot. **33**: 417–486. 1899.

NEWS.

MR. ABEL A. HUNTER has been appointed botanical collector for the University of Nebraska.

THE UNIVERSITY of Geneva has conferred the degree of Ph.D. *honoris causa* upon M. Casimir de Candolle.

DR. CARL E. CORRENS has been advanced to the assistant professorship of botany in the University of Tübingen.

DR. WILHELM FIGDOR has been appointed docent for anatomy and physiology of plants in the University of Vienna.

HOUGHTON, MIFFLIN & CO.'s fall announcements include a book entitled *Animal and plant lore*, by Mrs. Fanny D. Bergen.

DR. J. M. JANSE, of the botanical garden at Buitenzorg, Java, has been appointed professor of botany in the University of Leiden.

DR. K. GIESENHAGEN, of Munich, has received from the government a subvention of *M*6000 for an investigating tour to Malacca.

DR. L. HILTNER has been appointed director of the bacteriological laboratory of the biological division of the Imperial Bureau of Hygiene in Berlin.

PROFESSOR GEORGE W. MARTIN, teacher of biology in the Indianapolis High School, has been appointed professor of biology in Vanderbilt University, Nashville, Tennessee.

MR. C. G. PRINGLE has returned from his fifteenth year in the collection of Mexican plants. His health has not been good, but, as usual, he returns with a collection of choice plants.

DR. PAUL KNUTH, of Kiel, has returned to his home from his journey around the world. He has brought with him abundant ecological material from Java, Japan, and California.

IN A RECENT FIRE which destroyed the entire stock of Jacob North & Sons, in Lincoln, Neb., all the unsold copies of Pound and Clements' *Phytogeography of Nebraska* were burned.

DR. AUGUST N. BERLESE, heretofore professor of botany in the University of Camerino, has been appointed professor of natural sciences in the Royal Lyceum. Dr. J. B. DeToni has been appointed to the position thus

vacated by Professor Berlese. Dr. DeToni's address, however, will still be Padua.

ON MAY 1 the north wing of the great temperate house at Kew Gardens was opened to the public. The center of this house was built in 1862, and the south wing in 1894. The building is 628 feet long, with a maximum width of 164 feet and a height of 60 feet. It covers one and two thirds acres, and has cost £43,000.

THE INTERNATIONAL scientific medal of the *Academie Internationale de Geographie Botanique* has been conferred upon Dr. N. M. Glatfelter, of St. Louis, for his work upon Salix, and upon Dr. Roscoe Pound, of Lincoln, Neb., for his phytogeographical researches. Fifteen investigators in Europe have been similarly honored.

THE LINNEAN MEDAL has been awarded to Mr. J. G. Baker, late keeper of the herbarium and library of the Kew Gardens, "for his services to botany during a long series of years, especially his writings on ferns and petaloid monocotyledons, serviceable alike to botanists and cultivators." The presentation occurred at the anniversary meeting, May 24.

THE MACMILLAN COMPANY announce for publication this autumn a *Handbook of North American Myxomycetes* by Professor Thos. H. Macbride, of the University of Iowa. The work includes descriptions of all species hitherto described from North America, with brief synonymy, accompanied by diagnostic notes. The work is to be illustrated by nineteen full-page plates.

BY THE cooperation of a local mountain club, Dr. R. von Wettstein, the director of the Vienna botanical garden, has been enabled to establish a biological experiment station in the Tyrolese central Alps near the "Bremer-Hütte" in the Gschnitzthal, at an elevation of 2300^{m}. A room in the cottage has been fitted up for a laboratory. Research will be directed first to the production of species by direct adaptation.

MR. C. L. POLLARD of the National Museum, aided by Professor E. L. Greene, has undertaken the distribution of authentic sets of North American Violaceæ. Forty sets are in preparation and the museum offers them in return for an equivalent amount of selected duplicates, either in the Violaceæ or other groups. Decades will be issued at irregular intervals, as rapidly as material can be secured and labels printed.

THE POSSIBILITY of obtaining separates of articles from periodicals often renders possible the carrying on of investigations apart from the great libraries. We welcome, therefore, every establishment which facilitates the diffusion of such literature. Mr. A. I. Eriksson, Tufts College, Mass., is going into the business of dealing in natural history books and author's separates.

He will act as agent for authors who wish to dispose of any of their publications. A catalogue will be issued shortly.

AT THE MEETING of the St. Louis Academy of Science, held on the evening of October 16, Dr. H. von Schrenk presented some notes on *Arceuthobium pusillum*, which was found in Maine during the past summer, growing on the white spruce along the seacoast. The trees which are attacked form large witches' brooms, the branches of which are much longer than the normal branches. The manner in which the seeds are distributed was briefly described, and seeds were exhibited adhering to branches of the white spruce.

MR. O. F. COOK, of the Division of Botany, Department of Agriculture, has been detailed to make a preliminary examination of the plant products of Puerto Rico with reference to the introduction of new and useful tropical plants into that island. Mr. Cook is accompanied by Mr. G. N. Collins of the Department of Agriculture as photographer, and by Mr. George P. Gall, who is sent by the Smithsonian Institution to collect material for the National Herbarium. The expedition left New York on October 28 by the United States transport MacPherson.—*Science*, Nov. 3, 1899.

THE DISTINGUISHED French horticulturist Henri Lévêque de Vilmorin was stricken by apoplexy and died at Verrières on August 24, in his fifty-seventh year. He visited this country in 1893, when many of our botanists had the pleasure of meeting him at Madison, Wisconsin. Henry Vilmorin was not only the head of the historic house of Vilmorin & Co., the largest seed firm in France, but personally directed in large part the numerous experiments for the improvement of cultivated plants which the firm were continually conducting at Antibes, Verrières, and Ferme de St. Fiacre. Vilmorin was widely honored by scientific societies and has made valuable contributions to horticultural literature.

ON MARCH 3, 1899, a bill was passed by Congress providing "that on or before January 1, 1903, the fence around the Botanical Garden shall be removed; provided that at the first session of the LVI Congress the Joint Committee on Library is directed to report a bill embodying a plan for removing the Botanical Garden to another location." The present Botanical Garden is far too restricted to serve the purpose of a national establishment. With the rapid development of such gardens as those at New York and St. Louis, the national garden at Washington becomes insignificant. The proposition to remove it is most commendable. The chief danger arises from the fact that a site suggested is so far removed from the centers of botanical work as to prevent the new garden from becoming of the greatest scientific service.

MR. WALTER T. SWINGLE, of the U. S. Department of Agriculture, has returned from eighteen months' travel in Europe, North Africa, and Asia Minor, where he has been studying the agriculture and horticulture, with a

view of introducing new agricultural industries into America. The journey was under the direction of the Section of Plant and Seed Introduction of the Division of Botany. He paid particular attention to the date industry of the Sahara desert, and to fig culture as practiced in Greece and Asiatic Turkey, since both of these industries are likely to be introduced very shortly into our own southwestern states. Incidentally he noted many points of great biological interest. The caprification of the fig is still practiced as described by Aristotle more than two thousand years ago, and a careful study of the commensalism and symbiosis of the fig plant and Blastophaga is by no means superfluous, but on the contrary very much needed, since all previous students have studied it at the same time of the year, and many doubtful points remain to be cleared up. Mr. Swingle is going to California very shortly to study the fig industry of our own Pacific coast.

PROFESSOR W. A. SETCHELL, Dr. W. L. Jepson, Mr. L. E. Hunt, and Mr. A. A. Lawson, of the University of California, have returned to Berkeley from a botanical expedition to Unalaska. Dr. Jepson studied the flowering plants, Professor Setchell and Mr. Lawson the flowerless plants, while Mr. Hunt, who is in the Civil Engineering Department, determined altitudes and took the photographs of plant communities, etc. The party remained at Unalaska for eight weeks and carried out its work as planned, collecting thoroughly in the neighborhood of Unalaska bay, making extensive field notes, and securing a fairly full collection of photographs. Professor Setchell left Unalaska for about three weeks, on a trip to St. Michael and Cape Nome, collecting plants of all kinds and making notes as to points of distribution and ecology. Returning, the party went from Unalaska to Sitka along the coast, collecting at Unga, Karluk, Kodiak, Orca, Juneau, and Sitka. They were thus able to trace many plants of the shores along a considerable portion of the Alaska coast, and to note the changes in habit and the difference in altitudinal distribution. There is a very considerable amount of material accumulated and it will not be known until it is carefully worked over how much of it is new, or just to what extent it will throw light on matters of distribution. The collections of marine algæ, taken in connection with other collections made in Alaska, Washington, California, and Mexico during the last four or five years, it is hoped, will indicate the limits of the various algal floras of the Pacific coast of North America when they are properly determined and tabulated, and will afford the basis for some exact inquiry into the causes of demarcation.—*Science*, Oct. 13, 1899.